

The Australian and New Zealand Journal of Surgery

OCTOBER, 1944.

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Royal College of Surgeons of England.

JACKSONIAN PRIZE.

THE Council of the Royal Australasian College of Surgeons has been advised by the Council of the Royal College of Surgeons of England that the subject chosen for the Jacksonian Prize for the year 1945 is as follows: "Bone Grafting in Surgery: Its Indications, Methods and Results." Full details governing the conditions of the prize may be obtained from the Secretary of the Royal Australasian College of Surgeons, Spring Street, Melbourne, C.1.

Editorial Notices.

ALL articles submitted for publication in this journal must be typewritten and double or treble spacing should be used. Each article should conclude with a brief summary and statement of conclusions. Authors are requested to avoid the use of abbreviations and not to underline either words or phrases.

Authors are requested to submit two typescript copies of all articles.

References to articles and books should be carefully checked. In a reference the following information should be given without any abbreviation: initials of author, surname of author, full title of article, name of journal, volume, full date (month, day and year), number of the first page of the article. If a reference is made to an abstract of a paper, the name of the original journal, together with that of the journal in which the abstract has appeared, should be given, with full date in each instance.

When illustrations are required, good photographic prints on glossy gaslight paper should be submitted. Line drawings, charts, graphs and so forth should be drawn on thick white paper in Indian ink. Authors who are not accustomed to prepare drawings of this kind, are invited to seek the advice of the Editor if they are in any doubt as to the correct procedure. Skiagrams can be reproduced satisfactorily only if good prints or negatives are available.

Editorial communications should be addressed to the Chairman of the Editorial Committee, 57 Collins Street, Melbourne, or to any member of the Editorial Committee. It is understood that original articles forwarded for publication are offered to THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY solely, unless the contrary be stated.

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Business communications and remittances should be addressed to Butterworth and Co. (Australia) Ltd., 6-8 O'Connell Street, Sydney.

The announcements appearing in this journal contribute largely towards the maintenance of the high standard of the publication. It is, therefore, requested that, wherever possible, readers will support the business houses whose advertisements appear in the journal and that, when placing their orders, they will mention THE AUSTRALIAN AND NEW ZEALAND JOURNAL OF SURGERY.

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PRACTICAL POINTS IN PLASTER TECHNIQUE: TWO YEARS OF EXPERIENCE IN FORWARD SURGERY WITH A ROYAL ARMY MEDICAL CORPS (MOBILE) CASUALTY CLEARING STATION, 1941-1943.¹

By LINDSAY S. ROGERS,
Major, Royal Army Medical Corps.

GENERAL.

THE surgeon in forward areas fulfils two main functions: (*a*) the saving of life from immediate and grave battle injuries and (*b*) the treatment of many other wounds, chiefly injuries to muscles and compound fractures. The first function will occupy some 10% of his time, so that the second is seen to bulk much more largely. The permanent relief of pain and the minimization of sepsis in an already infected wound stand out prominently amongst the objectives of surgery as practised in a casualty clearing station. The surgeon there needs few instruments and little academic knowledge, but requires above all experience. With experience come many tricks of the trade which make his work easier and more effective. Complete immobilization may be regarded as the keynote of all. It banishes pain, it relieves shock, it lessens sepsis and allows healing to begin while the patient is still far from a base hospital where more effective measures are possible. Complete immobilization is just as necessary for "fractures" or injuries of the muscles and skin as it is for those of bone.

PLASTER FOR IMMOBILIZATION.

Four types of plaster of Paris have been available:

1. Loose Army plaster of Paris. This is the most useful of all. It is easy to carry in bulk, is of good quality, and is easy to make up into bandages of any width. It is slightly slower in setting than "Cellona", and is cheaper. Indeed, our best plasters were made from alternate bandages made with loose plaster of Paris and "Cellona".

2. "Cellona", six inches. This makes the smoothest plaster. It is quick in setting, strong and the case can therefore be made thinner and lighter. It is easy to work with, its only disadvantage being its bulk in transit, which is considerable.

¹ Accepted for publication on April 5, 1944.

3. German plaster of Paris. This is usually six inches in width, and proved good if the bandage was first taken and shaken, each end being held in the process. Resulting plaster cases were good, but took longer to set and required to be made thick and strong.

4. Italian plaster of Paris. This was useless. Even if the bandages were rewound into two, it was unsatisfactory because of its slow setting. The use of salt water or warm water made little difference to this.

In making or ordering plaster of Paris bandages, we have found a ratio of three six-inch bandages to one four-inch bandage a good rule.

A plaster must be strong to serve its purpose. Often one saw on arrival of a convoy broken and therefore pain-producing plasters. Lower limb plaster cases usually break just about the ankle or just below the knee, and should therefore be made stronger in these positions. Greater strength in these positions is required in a plaster used for travelling than in one put on at a base hospital.

Slabs are always broken, and are therefore mentioned only to be dismissed.

Adequate length is another important feature. Many plasters arrive too short, and as a result do not fulfil their function. Many patients come with the toes unsupported and therefore subject to pressure from the blankets. Plasters for the lower leg arrive with the plaster prolonged about four inches above the knee. This part usually softens, and the limb having shrunk a little, movement at the knee readily takes place. It is better therefore to carry these plasters higher—indeed, as a routine, up to the groin—in order to avoid a painful limb. Application from the groin to beyond the toes is advised.

Adequate padding is also important. Opinions on this subject notoriously differ, and this casualty clearing station has undergone a reversal in technique from the completely "skin-tight" closed plaster to a split, lightly padded cast. The artistry of the non-padded has given way to the safety of the padded cast. We have, however, always used felt over the heel and the malleoli, particularly the heel, for it is of little avail to have the tibia and fibula united at the end of ten weeks if the slough over the heel has not yet separated. It is thought better thus to play for safety, for once the patient leaves the casualty clearing station the delays may be of almost any length until the next hospital or medical area is reached. Where wool is not available, "split Gamgee" has been used. It is not so good, but can be made to answer the purpose.

Finally, a plaster must be easily and painlessly removable. Such incidents as the swelling of a limb, a bony point becoming painful, or some similar misfortune may arise at any time and call for immediate removal of the plaster cast. Padding prevents unshaven hairs from sticking to the plaster, and the use of the "greased pig" makes splitting and therefore removal easy. The greased pig is a thick, round, rubber tourniquet liberally smeared with "Vaseline" and laid on the limb after the limb has been covered by wool. The plaster is now applied in the usual way over the tube, and when it has just set the tube is pulled out, an elevated tunnel thus being left down the whole length of the cast. This is cut open at once, two inches being left intact at each end for the purpose of holding the ends of the plaster together. Should now an urgent removal of the plaster become necessary, it is a simple matter to cut the two ends. The splitting of the plaster allows of expansion of the limb to minor degrees, and thus makes the cast safer without the loss of any of its powers of immobilization.

THE TECHNIQUE OF APPLYING PLASTERS.

The theatre orderlies should be used as a team. This organization makes each one proficient in his own job. Good team work halves the time taken and results in better casts. The soaking of the bandages, for example, requires practice to get them just right to suit the individual surgeon's requirements. The holding of the knee in flexion is another difficult task to perform without awkwardness and interference with the work of the surgeon.

Each layer of the plaster should be smoothed out as it is applied. This incorporates the plaster evenly, and makes a stronger cast.

The plaster should be moulded in the hollows, particularly round the ankle. This is done with the palm of the hand and not the fingers.

The best time for "finishing" the plaster is when the plaster has just not quite set. The finishing should be deferred until this moment.

The assistants should support the limb not with their fingers but with the hollow of the hand.

Each patient in plaster should be kept if possible for two days. The first day is for thorough drying and setting, and the second to make sure that the plaster is comfortable. Every complaint about pain in a limb in plaster should be listened to. Pain means that something is wrong, and when pain is present plasters should be reapplied until they are comfortable.

PLASTER SKULL CAPS FOR HEAD WOUNDS.

The chief causes of trouble in plaster skull caps for head wounds are that they are either too tight and cause headache and pain with œdema round the eyes, or else they are too loose and fall off.

To avoid these troubles use plenty of wool, keep the ears free and bring the plaster well down over the occiput. Bring three turns of the plaster under the skin like a chin-strap, and use the greased pig, commonly transversely over the skull. Painless and easy removal results.

WOUNDS OF HAND AND WRIST.

The chief causes of trouble in plasters for wounds of the hand and wrist are: Slabs are too thin and break at the wrist. Slabs are not moulded around the arm to grip it. Slabs do not in certain cases extend beyond the finger tips to protect them against jarring. Circular plasters cause stiff fingers and often swelling beyond. To avoid these troubles, the wound is attended to in the usual manner and a wet, shrunk bandage is applied round the arm down to the hand. A thick, long, wide slab is made and applied over the volar surface of the arm from just distal to the elbow joint to well beyond the finger tips. It is moulded round the arm and into the palm, with the hand slightly dorsiflexed. The piece projecting beyond the finger tips is then bent back dorsally and heaped up to form a small bar just distal to the finger tips. The rest is moulded back to strengthen the wrist part. The rim thus formed distal to the finger tips prevents movement, prevents injury and makes a comfortable support in which the fingers can move if this is desired. A cast of this type is extremely useful in all inflammatory infections of the hand, and is recommended for these. It can be modified to suit conditions, but in the main it stops pain, limits infection and allows early resolution.

PLASTERS FOR FRACTURES IN THE LOWER LIMB.

The chief causes of trouble here are the following. Toe supports are very thin and broken or not applied at all. Weak, broken plasters, mainly below the knee or just above the ankle, are common. Casts sometimes do not

extend high enough and allow movement at the knee joint. There is no felt under the heel or over the malleoli. The plaster is not split and therefore difficult to remove. The foot is put up in plantar flexion. A slab alone is used, which usually arrives broken. Cramer wire is used, which is usually insufficiently padded and insufficiently fixed.

The avoidance of these troubles is managed along the following lines. The limb is held in abduction, extension and slight flexion at the knee, with the foot in plantar flexion. Cotton wool in rolls is applied from the groin to the toes. Three pieces of felt are held ready, one for the heel and one for each malleolus. The greased tourniquet is laid lengthwise down the limb over the wool, the metal end being caught between the first two toes and the other end being left at the groin. The plaster is applied first at the thigh and a strong and adequate case is made. A pause is made after covering the knee so that the plaster may set with the knee in slight flexion. The rest of the plaster is then applied to the toes, the heel traction being kept up and care being taken that the foot is in the neutral position. A slab is now made about twenty inches long, out of two six-inch bandages. It is applied to the back of the calf and up to the toes, so that six inches overlap the toes on the dorsal aspect. The slab is bound to the cast up to the toe level, after which the six-inch overlap is turned back to the plantar surface, the slab thus being doubled and a shelf being left projecting one inch beyond the toes. A small slab of "Cellona" about ten inches long, made from four-inch bandage, is laid across the end of the major slab. The ends of it are then brought down on each side of the foot. The plaster is finished with one four-inch bandage. This plaster is an adequate one, the toe cap never breaking. The toes should be seen to be capable of full movement.

PLASTER FOR LARGE WOUNDS OF THE THIGH AND FRACTURED FEMUR.

From a casualty clearing station standpoint, the only type of immobilization which has stood the test of desert travel is the "Tobruk plaster". It is rarely seen in its best and original form. Immobilization is the only principle of importance as far as the casualty clearing station treatment of fractured femur is concerned. Traction or extension by hand will accomplish little in the correction of alignment or overriding of fragments. All it will do, and that not nearly so efficiently as a satisfactory plaster, is to produce a moderate degree of immobilization. Overriding and angulation should be corrected at the general hospital, and whether this is produced by prolonged weight traction or by mechanical means does not concern the casualty clearing station surgeon. The Tobruk cast produces the best immobilization possible, and therefore extension is in our opinion unnecessary. Some still desire it and therefore we have included it in our technique.

The chief causes of trouble in these cases are the following. The plaster is wound round the Thomas splint as well as the leg and therefore rotation of the limb may take place. The plaster is not long enough. Extension cords are loose or strapping has slipped, allowing movement in an inadequately plastered limb. The knee is not flexed. The foot is in plantar flexion and often has no padding behind, leading to painful heel or painful malleoli. Stretcher bars are used for foot supports. The ring is too small and does not reach the ischium, or is too large and rides over it. There is no padding between the outer side of the thigh and the ring.

These troubles may be avoided in the following way. The wound is attended to and dressed. A suitable Thomas splint is chosen and bent at the knee and slings are made. For those who desire extension, the leg is shaved and strapping is applied from the mid-thigh to beyond the toes, padding being

put between the strapping and the malleoli. The whole limb is padded with wool and a complete plaster is applied from just distal to the groin to the toes, the knee being included in a slightly flexed position, the toes with a good stout toe support, and the foot in a neutral position. A "greased pig" is used to allow of splitting. A felt pad is placed under the heel. The encased limb is now put into the Thomas splint. The ring is pushed well against the ischium and well into the adductor region. Care is taken that the bend in the Thomas splint corresponds to the flexion of the knee. Three shell dressings are now used. One is pushed in between Scarpa's triangle and the ring, and the other two between the outer aspect of the thigh and the ring. The ends of the extension strapping are now tied and fixed to the end of the Thomas splint by a cord. A Spanish windlass is inserted and twisted tight. The leg encased in a complete cast is now fixed immutably to the Thomas splint by three four-inch "Cellona" bandages. One is placed at the ankle, one at the knee and the other at the ring, the shell dressings being just taken in so as to fix them. The "greased pig" is withdrawn and the cast is cut, the customary two inches being left at each end. A Sinclair's footpiece (the iron hoop) is now firmly fixed to the end of the Thomas splint by a plaster bandage. This does away with the stretcher bar and allows the patient to be nursed in bed and handled easily in air transport. It supports the splint and the limb perfectly by putting its foot between two folded blankets.

In the case of fractures of the femur, high in the shaft or at the neck, we have used a technique similar to the above, but have prolonged the cast proximally, so that it follows the line of the groin to the iliac crest, thus grasping the trochanter. The ring of the Thomas splint in this case will not slip over the proximal end of the plaster, but rests on it. Any attempt therefore at extension is impossible. This method combined with the use of a stretcher bar to anchor the distal end of the limb firmly, allows the patient to travel comfortably.

The points in favour of this method are:

1. There is no rotation of the limb possible inside the plaster, for the limb and foot are encased.
2. The foot cannot drop or twist, and the toes cannot become painful, because all are supported and at the same time free toe movement is allowed.
3. The raw surfaces of the wound itself are given immediate support.
4. Practically no hip joint movement can take place if the end of the splint is fixed.
5. The method is simple, quick and always in our experience efficient.

PLASTERS FOR WOUNDS OF SHOULDER GIRDLE AND HUMERUS: THE THORACO-BRACHIAL CAST.

The chief causes of trouble with plasters for wounds of the shoulder girdle and humerus are the following. No padding is placed over the shoulder girdle; no padding is placed under the olecranon; this plaster is used for supracondylar fractures of the humerus, for which it is unsuitable and dangerous; the elbow is too far back, so that the cast rests on the iliac crest when the patient is in bed. The arm is not flexed; the hand is not supported in slight dorsiflexion (very common); the plaster is too low and cuts into the anterior abdominal wall; the upper arm is encircled with plaster and resulting pain and swelling in the lower arm, and the hand is uncomfortable and makes the plaster very difficult to remove. The whole plaster is ill-fitting and loose, owing to its application to an unconscious patient.

These errors may be avoided by adoption of the following measures. On the patient's arrival, an anaesthetic is given, the wound is treated and dressed, and the limb is bandaged to the side of the chest wall with a strong flannel bandage, the arm being kept in flexion. Next morning the following preparations are made. Fourteen six-inch plaster bandages, four shell dressings or two large pads of felt, two rolls of wool to fill in the gutter between the arm and the chest wall and one wet bandage are used for the forearm; and two six-inch good soft bandages are used for keeping the pads in position and for the protection of a hairy chest.

One hour before the patient is brought to the theatre morphine, grain one-quarter, and scopolamine are given. A further dose of morphine is given intravenously. The patient's cooperation is sought by explanation as to the procedure. He is made to sit up in the stretcher and the bandage over the forearm put on the night before is cut off. The forearm is now bandaged with the wet bandage, and a good volar slab is applied to the heads of the metacarpal bones. This is allowed to set hard, being the permanent hand support. The patient is now made to sit on a stool. His feet are widely spaced to get a good base, with someone holding his hand firmly. The rest of the previous night's bandage is removed quickly, the whole arm being freed and incidentally considerable pain being caused for the time being.

A large pad of felt is applied over the injured shoulder girdle, care being taken that it covers the spine of the scapula, the lateral aspect of the humerus and the clavicle. Three shell dressings do equally well for this purpose. Over the olecranon a thick felt pad is applied and everything is bound on, the two rolls of cotton wool being put in the gutter between the chest and the arm. We use two six-inch bandages for this in a modified Velpeau technique. The arm is kept flexed with the elbow brought forward towards the mid-line. The forearm is kept free from the bandage and is kept held with a slight forward rotation to allow room to work between it and the chest wall.

The plaster is now applied, a triangle being made with the base extending from the base of the neck to the olecranon on the injured side, and the apex under the opposite axilla. Slabs are used to strengthen this. One extends from the base of the neck to the olecranon and embraces it. The other from the vertebral groove passes round and forward to wrap round the lower and outer third of the humerus.

The whole humerus is now completely encased, and all that remains is to fix the forearm by means of a plaster sling in a flexed position over the front of the chest. With a six-inch bandage a start is made over the injured shoulder, a sweep downwards is taken over the flexed forearm, underneath it, and then up under the opposite axilla and so on to the original starting point. Three bandages suffice for this purpose.

At this stage the patient is no longer in pain. In contrast to his former condition, one of considerable anxiety and pain, he can now get up and walk away if too much morphine has not been given to allow that.

The Fixation of the Humerus.—Additional points in the fixation of the humerus are the following. The apex of the plaster under the opposite axilla should be made narrow and firm. The cast should be kept as high as possible, so that it does not chafe the abdominal wall when the patient is in the sitting position. There should be free movements to the fingers and support for the hands. The whole cast should fit snugly, allowing little or no movement between the body and the cast.

This procedure of applying a thoraco-brachial cast is the most dramatic procedure a casualty clearing station ever does for a conscious patient.

PROCEDURES THAT HAVE BEEN ABANDONED BY OUR CASUALTY CLEARING STATION IN THE FIELD.

The following procedures and apparatus have been abandoned by our casualty clearing station in the field: skin-tight unsplit plasters; Cramer wire splintage; posterior leg slabs; failure to support the toes; the making of a search for foreign bodies in a comminuted fracture; any new modification aimed at reducing the amount of plaster in a Tobruk plaster; the application of a thoraco-brachial cast to an unconscious patient; plaster spicas; treatment of a large flesh wound without a plaster of Paris support; any method which allows a hand to flap loose in a thoraco-brachial cast; the use of circular or enclosing plaster casts for wounds of hands and wrist; the treatment of an I.A.T. hand or finger without fixation; finally, failure to listen when a patient complains of an ill-fitting or painful cast, and to take the appropriate action. The last mentioned is the most important point of all.

THE IMMEDIATE AND LATE TREATMENT OF AN ARTERIO-VENOUS FISTULA.¹

By EMILE HOLMAN,
Commander, Medical Corps, United States Navy Reserve.

ONE may confidently predict that many abnormal communications between the larger vessels will be established by wounds sustained in this war and that they will provide, unless early and successful treatment is available, some very interesting clinical phenomena and difficult problems both for the internist and the surgeon. In 1937 Basil Price⁽¹⁾ recorded his experiences with five patients from the last war whose arterio-venous wounds were sustained twenty years previously. In three instances operations had been considered impossible because of advanced cardiac disability and two patients had died, one from a ruptured varicose vein distal to the fistula and one from cardiac failure. The third patient will undoubtedly die of cardiac decompensation unless an operation for the elimination of the fistula can be performed successfully, a possibility which may still be considered despite the cardiac disability. Even advanced cardiac failure with generalized œdema, ascites and hydrothorax has been cured completely by the elimination of an arterio-venous fistula.⁽²⁾ In Price's two remaining cases incomplete operations have improved, but have not cured the lesions. Increasing cardiac disability directly due to the fistulae may be expected as time elapses.

The lesion provides one of the most fascinating examples of pathological physiology:⁽³⁾ the introduction of a fistula into the circulation superimposes upon the normal circulatory bed a second or fistulous circuit which is in reality parasitic upon the first (Figure I). The normal circulation consists of the heart, arterial bed, capillary bed and venous bed. The fistulous circuit consists of the heart, the artery between the heart and the fistula, the fistula and the vein between the fistula and the heart. Common to both systems are obviously the heart, the artery to the fistula and the vein from the fistula to the heart. Each system requires a certain volume of blood to satisfy its needs, the need of the fistulous circuit depending upon the amount of blood which the fistula is capable of transmitting. Experimentally and clinically, when the parasitic circulation attracts to it the greater volume of blood, the animal or patient dies.

The effect of the diversion of blood from the normal arterial bed into the parasitic circuit is many fold: there occurs (a) a lowering of blood pressure comparable with that accompanying massive external bleeding from a large vessel; (b) an accelerated pulse rate as a compensation for the lowered blood pressure and as a response to the increased venous filling of the heart; (c) a great increase in cardiac output, indicating a greatly increased volume flow of blood through the fistulous circuit; (d) a temporary or fleeting reduction in the size of the heart and of the artery proximal to the fistula, due to a redistribution of blood from the central arterial to the peripheral venous bed.

The loss of blood from the normal circulation with its concomitant fall in blood pressure is at first rectified, as in any bleeding to the outside, by the accretion of fluid from the tissues and by cells and fluid from such organs as

¹ The opinions contained herein are the private opinions of the writer and are not to be construed as official or as reflecting the views of the Navy Department or the Naval Service at large. Accepted for publication on August 29, 1944.

the spleen and liver. This restoration of the circulating blood to a volume adequate to meet the needs of both the normal and parasitic circulations results in: (a) a recovery of systolic blood pressure to normal, but a permanent lowering of diastolic pressure due to a permanently decreased peripheral resistance at the site of the fistula; (b) a return of the pulse rate to a more normal figure, although at times the acceleration may persist; (c) an increased total blood volume; and (d) an increase in the volume of blood flowing through that part of the circulatory system common to both the normal and parasitic circuits.

This increased volume or bulk of blood flowing through the fistulous circuit including the four chambers of the heart, distends and dilates it to a greater or less degree, depending on the volume flow through the fistula. Experimentally it has been proven that the entire part of the circulatory bed through which the short-circuited blood passes, becomes dilated.

The interdependence of the size of the normally functioning heart and of the volume flow of blood through it has been demonstrated also under other conditions. In massive bleeding the removal of 500 cubic centimetres of blood from the circulation of a twelve-kilogram dog will reduce the heart to one-half its normal size. In shock the size of the heart is greatly reduced owing to redistribution of the normal blood volume. In histamine shock the peripheral vasodilation causes the blood to leave the central circulatory bed and to accumulate in the peripheral vascular bed. In traumatic shock the blood leaves the central bed and accumulates in the traumatized area. Similarly, on opening a fistula the blood leaves the normal arterial bed and fills the capacious, easily distensible venous bed, and the heart temporarily decreases in size. Experimentally, however, this initial decrease in the size of the heart is very fleeting, lasting perhaps a few hours to a few days, after which there occurs a gradual dilatation of the heart and of the vessels leading to and from the fistula, in some instances to an enormous size.

This gradual dilatation of the fistulous circuit which often continues over a period of years, is explained as follows. The peripheral resistance at the site of the fistula in circuit PN (Figure I) is obviously less than the peripheral resistance in the arteriolar and capillary bed of circuit N. Flowing blood, like flowing water, seeks the path of least resistance. The tendency, as long as a difference in peripheral resistance persists, is to force at each heart beat a little more blood through the fistula at the expense of the blood flowing through the normal capillary bed N. But the blood loss from circuit N is promptly made good by an increase in the total volume of circulating blood, resulting inevitably, though slowly, not only in a gradually increasing volume of blood flowing through that part of the circulatory bed common to both circuits but also in its dilatation. The determining factor in this gradual dilatation is the extent of the difference in the peripheral resistances in the two circuits, which in turn

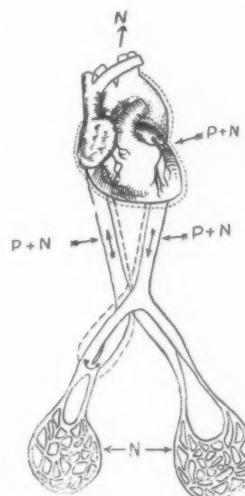


FIGURE I. The introduction of fistula into the arterial bed provides a parasitic circulation P which abstracts a varying volume of blood from the normal circulation N. That part of the circulatory bed common to both P and N circulations will dilate to accommodate the increased volume of blood coursing through it.

is determined by the size of the rent in the artery producing the fistula, by its location in the arterial tree, and by such fortuitous conditions as the amount and firmness of the fibrous tissue deposited in the process of healing around the fistula, around the vein proximal or distal to the fistula, and around the artery proximal to the fistula. If this fibrous tissue is considerable and the fistula is small, a point will be reached rather promptly at which the peripheral resistances in the two circuits will become equalized, at which there will be no further increase in the volume of blood flowing through the fistula, and at which no further dilatation of the fistulous circuit will occur. Such equalization may be indefinitely postponed when the fistula lies between vessels that offer little resistance to their dilatation, as in the abdomen, pelvis or upper part of the thorax, or when the fistula itself has a minimal amount of fibrous tissue deposited around it, permitting its easy though slow dilatation. The slowly progressive dilatation of the heart that occurred in a few clinical cases observed twenty-four, twenty-five and twenty-six years^(a) after the inception of the fistulae is explicable only on the basis of this slow dilatation of the fistula itself, producing, in effect, a vicious circle. The extent of the fibrous deposits around a fistula and the involved vessels may determine the great variation in the effects upon the circulation of fistula located in the same general region in the vascular bed. If an injury to the vessels is accompanied by chance by a mechanical block in the proximal vein, an easy return flow to the heart being thus prevented, the effect upon the circulation and upon the heart will develop much more slowly than in the absence of such a block. Mason^(b) records cardiac decompensation in a subclavian fistula within nine weeks of its inception, whereas in a patient observed by me seven years elapsed before cardiac decompensation appeared in the presence of a subclavian-jugular fistula.

A most important factor in determining the effect of a fistula upon the circulation is its location in the arterial tree. The nearer the fistula is to the heart, and the larger the vessels involved, the greater will be the discrepancy between the high pressure in the artery and the absence of pressure in the vein. As a corollary to this it may be said that the larger the injured artery, the greater will be the capillary bed normally supplied by this artery, and therefore the greater will be the peripheral capillary resistance beyond the point of injury or communication with the vein. The difference between the negligible resistance in the fistulous circuit PN (Figure 1) and the peripheral resistance in the vascular bed N beyond the fistula will determine not only the amount of blood diverted through the fistula but the resulting effect of the fistula upon the circulation. A fistula 15 millimetres long between the aorta and *vena cava* in a dog is almost invariably fatal, whereas a fistula 15 millimetres long between the femoral vessels will produce cardiac dilatation and decompensation only after years have elapsed.

Other factors influence the ultimate effects upon the circulation. If the tangential wound in the artery produces a fistulous opening larger than the proximal artery, and is therefore capable of transmitting more blood than this artery can supply, the arteries in the collateral bed surrounding and proximal to the fistula will open up to pour their quota into the parasitic circuit, to satisfy, as it were, its thirst for blood. This stimulus to the development of the collateral circulation is entirely due to the ease of flow through the site of decreased resistance at the fistula, and is not dependent upon the need of the tissues beyond the fistula, as Reid^(c) and Lewis^(d) have suggested.

The very occasional and rare dilatation of the artery distal to a fistula^(e) is easily duplicated in the laboratory animal by establishing a fistula and then tying the artery proximal to the opening. The site of diminished peripheral

resistance at the fistula attracts blood from all available collateral arteries connecting with the branches of the artery distal to the fistula. The resulting greatly increased volume of blood flowing back through the distal artery into the fistulous circuit produces a dilatation of this artery distal to the fistula. These experimental observations demonstrate the intimate relationship between the decreased peripheral resistance to the flow of blood through the fistula and the development of collateral circulation, and the intimate relationship also between the volume flow of blood through an artery and its resulting dilatation. Clinically, obstruction of the artery proximal to a fistula may occur owing to fibrous tissue deposited in the course of healing, and as a result dilatation of the artery distal to the fistula may be observed.

Closing a fistula either by digital compression or by operation results in a reversal of all these various effects upon the circulation: the elimination of the parasitic circulation directs the blood formerly short-circuited into the fistulous circuit into the general arterial bed, distending it with a volume of blood abnormally increased in the presence of the fistula. The effect is that of an autotransfusion. The distension of the arterial system includes not only the already dilated heart, which temporarily becomes even more dilated, but also the arch of the aorta whose depressor fibres of the vagus nerve are stimulated, a reflex retardation in pulse being produced. This is a protective and natural response to the abnormally high blood pressure incident to the abnormal distension of the arterial tree. Experimentally and clinically it has been shown that the increase in blood pressure precedes the retardation in pulse, both phenomena being dependent upon the increase in total volume of blood.

This overdistension and high blood pressure following permanent elimination of a fistula are promptly rectified by a reduction in total blood volume through loss of blood plasma, as shown by an excessive urinary output and by a concentration of blood in the first twenty-four hours after closure of a fistula. As a result of this decrease in total blood volume and of the diminution in volume flow of blood through the fistulous circuit, there occurs a rapid decrease in the size of the heart, and except for a very slight hypertrophy that has occurred during the life of the fistula, the heart will be restored practically to normal size within six to ten days.

It is obvious from the foregoing observations that a fistula large enough to produce circulatory changes must be eliminated from the circulation to avoid a slowly progressive cardiac disability from cardiac overdistension, a complication that may occur promptly after the introduction of the fistula or as long as twenty-five or thirty years later.

The following sequence of clinical events usually accompanies a fistula: dyspnea and tachycardia on the slightest exertion, an increasingly vigorous beating or "pounding" of the heart, a progressive dilatation of the heart, followed inevitably in the presence of a large fistula by complete invalidism and death. There may also follow in the wake of the fistula various local manifestations, such as œdema of the extremity, often elephantiasic in type, and marked varicosities complicated by eczema, ulceration and occasionally bleeding.

A patient in whom an injury to a large artery is suspected, is placed in a hospital for continuous and careful observation. If, under bed rest, the bleeding ceases and there is no increase in the swelling of the limb due to an enlarging haematoma, nor evidence of developing infection, further delay in operating is advisable. An increasing haematoma at the site of the injury or an increasing swelling of the limb which threatens the blood supply of the extremity beyond it, as shown by a cold, œdematosus and pulseless leg or arm,

requires immediate operation. The operation at this stage is performed preferably under a tourniquet, the haematoma is evacuated, a localized *débridement* is carried out, and the injured vessels are exposed. In the absence of any evidence of infection and if the arterial wound is small and unaccompanied by loss of substance, suture of the wound may be attempted. The vein is ligated to avoid the danger of an embolus either of air or blood clot. If such suture is impossible, the ligation and division of the artery and vein are in order. Repeated and massive transfusions are indicated to maintain and raise peripheral arterial pressure, since this is the best guarantee that a limb deprived of its main artery will survive. Interruption of the lumbar or thoracic sympathetics either by repeated "Novocain" injections or by direct operation will encourage collateral circulation by promoting peripheral vasodilatation.

Should evidence of infection be present, the hazard to life is greatly increased. Under a tourniquet, if feasible, the wound is laid widely open, blood clots are removed, a *débridement* is carried out, the injured portions of the artery and vein are excised, and the four ends of the vessels are ligated. Every nook and cranny of the wound are liberally treated with sulphathiazole powder, smeared in as an emulsion or suspension in tissue fluids, and sulphonamides are given by mouth. Penicillin is administered in appropriate dosage.

If the wound to the artery appears trivial and the diagnosis is not immediately made (and this is often the case), operation should be deferred until all danger of infection is past. Indeed, the observation that small fistulae heal spontaneously has led Reid⁽²⁾ to advocate postponement of surgical intervention for six months. Experiments have shown, however, that only small fistulae tend to heal spontaneously, and that large fistulae do not. If, therefore, evidence develops that the heart is enlarging, that the thrill and bruit are increasing rather than diminishing in intensity, that variations in blood pressure and pulse can be produced by closing the fistula, and that these variations are becoming more rather than less pronounced, one may be certain that the opening will not close spontaneously and that it must be eliminated by operation to avoid further ill effects upon the circulatory system.

Reid emphasized also that delay in operating upon a recently formed fistula is indicated so that the collateral circulation may be developed sufficiently to permit division of the artery if necessary. This delay may be as short as five to six weeks, or as long as three to four months without the life of the patient being endangered. Other benefits of delay suggested by Reid are that the injured vessels become more thoroughly healed, thus making their dissection easier and safer and infection is less likely to occur. For these various reasons, unless cardiac failure is imminent, it would be preferable to delay operation upon an arterio-venous fistula for five to six months, at the end of which time spontaneous closure may have occurred.

An important pre-operative precaution in the case of a long-standing fistula exhibiting cardiac disability is to prescribe complete rest in bed for ten to fourteen days preceding the operation. Digital closure of the fistula, or of the artery proximal to the communication, for thirty to forty minutes three to six times a day will be very helpful in controlling or improving the cardiac disability. It acts, I believe, by reducing the amount of blood flowing through the fistula by encouraging fibrous contraction about the fistula. The condition of several patients was greatly improved before operation by this simple expedient.

Following the operative closure of a large fistula which has produced a marked dilatation of the heart, it is important to restrict activity for six to

eight weeks to permit the previously dilated and thinned out cardiac musculature to become readjusted to the increase in diastolic pressure brought about by closure of the fistula. An important precaution at the operating table is also related to this extreme dilatation of the heart accompanying a large fistula. Closure of the fistula not only raises diastolic pressure by an increase in peripheral resistance but also leads to an overdistension of an already dilated heart through a redistribution of the circulating blood, more than half of which formerly leaked into the capacious venous bed. Such overdistension of an already thinned out cardiac muscle might easily lead to recurrence or exacerbation of the cardiac decompensation. This would be revealed at the operating table by an increased pulse rate and a lowered blood pressure on closure of the fistula instead of the reverse. Should this occur, the operator should be prepared to do an immediate venesection in order to reduce the volume of circulating blood which had become considerably augmented during the life of the fistula.

In operating upon an arterial lesion certain fundamental principles must be observed. If a venous communication is overlooked, and the usual Hunterian ligation of the artery proximal to the lesion is performed, gangrene beyond the fistula is almost inevitable. The collateral circulation will find its way, not into the capillary bed distal to the fistula, but through the fistula back to the heart (Figure II). Hence the importance of accurate observations to determine whether the lesion is a simple sacculated aneurysm or an arterio-venous communication, since life itself may depend on the correct differentiation between these two conditions. The distinctive features of a fistula as compared with a simple aneurysm are: (a) the thrill and bruit are continuous but intensified during systole; (b) the slowing of the pulse and the rise in blood pressure on digital closure of the artery proximal to the lesion occur only in the presence of a fistula and never in the presence of a simple arterial aneurysm, since total blood volume is not increased in the presence of a simple aneurysm; (c) the high oxygen content of arterial blood withdrawn from the veins distal to a fistula as compared to the venous blood obtained from the veins of another extremity is a distinguishing feature suggested by Brown. If these evidences of a fistula are present, simple ligation of the artery proximal to the lesion is absolutely contraindicated.

The ligation of the artery and vein proximal to the fistula may occasionally be employed as a preliminary procedure in the hope that closure will be effected by thrombosis or by fibrous contraction at the site of the fistula. Usually the fistula is not cured, as the collateral channels will readily supply blood to the site of decreased resistance provided by the fistula. The ligation of the artery and restoration of the vein are definitely contraindicated, since the little blood that passes through the collateral channels will find its way promptly into the dilated venous bed, thus avoiding the distal arterial bed.

In certain appropriate cases, the Matas-Bickham procedure of transvenous or transsaccular aneurysmorrhaphy may be attempted. Under a tourniquet,

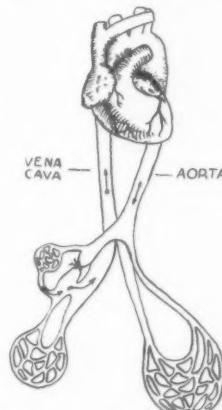


FIGURE II. Simple ligation of the artery proximal to an arterio-venous fistula, such as might be done proximal to a simple aneurysm, is absolutely contraindicated. It is obvious that the blood flowing through the collateral vessels would flow back to the heart through the site of the lessened resistance at the fistula, thus bypassing the peripheral vascular bed. Gangrene would be inevitable under these conditions.

the varicose sac or the dilated vein is boldly opened, and the rent in the artery is closed by suture. The vein should be ligated above and below the fistula. The wall of the vein may be employed to reinforce the sutured rent in the artery.

Ligation of the artery and vein proximal and distal to the fistula with excision of the fistula is the operation of choice for complete cure, and the one as a rule most easily executed (Figure III). A pulsating artery full of blood is so much more easily identified than a collapsed vessel that isolation and mobilization of the vessels are best accomplished without a tourniquet, the artery proximal and distal to the fistula being isolated first for control in case of bleeding.

If feasible, one should be prepared to apply a tourniquet at any time in the course of the operation.

Should complete mobilization and excision of the fistula be impossible because of involvement of important structures such as nerves embedded in dense fibrous tissue, ligation of the artery and vein proximal and distal to the communication without excision of the fistula is in order (Figure IV). Under such conditions, however, the artery proximal to the fistula should be ligated and divided to avoid reactivation of the fistula by the reopening of the artery through necrosis of the tissues included in the ligature.

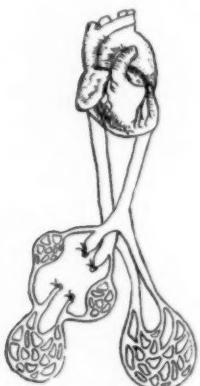


FIGURE III. The operation of choice for an arterio-venous fistula is quadruple ligation of artery and vein proximal and distal to the fistula with excision of the abnormal communication. A fistula which has been allowed to remain four months or longer, has usually so stimulated collateral circulation that ligation of the main artery to a limb can be performed with impunity.



FIGURE IV. If excision of the fistula is impossible owing to difficulty in mobilization because of excessive scarring or because of the inclusion of main nerve trunks in dense scarring surrounding the fistula, quadruple ligation without excision may be preferable. The proximal artery, however, must be sufficiently mobilized to permit ligation at two points and division between them. Ligation in continuity may lead to reestablishment of the arterial lumen and reactivation of the fistula.

Large pulsating aneurysmal swellings and arterio-venous fistulae of the upper part of the thigh, above which the use of tourniquets is impossible, require careful planning and special measures lest incision of the lesion engulf the surgeon and the operative site in a sea of blood, completely obscuring and defeating the object of the operation. An important maxim here, as elsewhere, is not to incise a pulsating swelling without first having attained complete control of the normal artery above and preferably also below the lesion. Complete control of bleeding when operating upon arterial lesions of the upper part of the thigh demands that both common and external iliac arteries be temporarily occluded. The inclusion in the temporary ligature of a segment of rubber tubing about the calibre of the artery prevents fracture of the wall of the artery which would invite later trouble at the site of temporary ligation. It enables one also to remove the temporary ligature without difficulty and without injury to the artery by cutting the tape ligature on the rubber tubing. Such temporary occlusion of the common

and external iliac arteries is best accomplished through a separate incision through the tendinous structures of the abdominal wall just lateral to the lower third of the rectus muscle, the peritoneum being displaced upward and the common iliac artery exposed at its origin. The lesion itself is approached through a longitudinal incision in the thigh directly over the common and superficial femoral arteries. Division of Poupart's ligament is avoided if possible. This incision for the exposure of the common iliac artery will also permit removal of the lumbar sympathetic ganglia for the production of peripheral vasodilatation, if this seems desirable.

In operations upon the large vessels of the neck, the hazards of bleeding are also greatly accentuated. To operate successfully upon arterial lesions in this area one must be able to expose the normal artery proximal to the arterial wound for temporary occlusion. One must be able also to occlude temporarily the proximal vein, not only to control bleeding, but also to avoid air embolism through accidental rents in the larger veins which in this region so frequently exhibit negative pressure during inspiration. To insure an exposure adequate for operations upon the subclavian and axillary vessels it has been found desirable and practicable to resect a considerable portion of the clavicle subperiosteally. No permanent damage has resulted from such resection, since retention of the periosteum has permitted reformation of the clavicle and restabilization of the shoulder within four to five weeks. The wide exposure of important structures permitted by resection of the clavicle provides greater confidence, the surgeon being at all times master of the situation should any untoward event occur, such as unexpected arterial bleeding, tearing of large veins, or the infliction of an injury on the larger lymphatics.

Ligation of the common or internal carotid artery may be accompanied by hemiparesis of the opposite side, due to nutritional disturbances in the cerebrum. Owing to a collateral flow through the external carotid artery, ligation of the common carotid is less dangerous than ligation of the internal carotid artery. Whenever ligation of either the common or internal carotid arteries must be done, Makins emphatically advises also occlusion of the internal jugular vein.

The success of operations upon the large vessels depends in great measure upon the avoidance of sepsis. The strictest precautions against infection must be followed throughout, and the liberal use of the sulphonamides locally and systemically is indicated in any contaminated or potentially infected wounds. Except in the presence of actual pus, drainage in vascular surgery must be scrupulously avoided. In surgery of the large vessels, to pack or to drain wounds is to invite almost certain disaster. Should the wound at any time following operation fill up with fluid, it is a simple matter to evacuate it under strictly sterile precautions. If there is any question of infection, penicillin should be promptly administered in maximum dosage. If drainage of a contaminated wound seems desirable, line the wound with heavily impregnated "Vaseline" gauze, but avoid touching the site of ligation or the line of suture in the artery by any foreign body such as the "Vaseline" drain. A foreign material lying against the site of ligature interferes with the deposition of fibrin and fibrous tissue around the ligature and invites secondary haemorrhage through necrosis of the arterial wall at the site of ligation.

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A REPORT OF FORTY CASES OF GUNSHOT WOUNDS OF THE CHEST TREATED AT A BASE HOSPITAL.¹

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WHILST Littlejohn suggests that operation for removal of a retained foreign body is often not necessary, King would advocate surgical interference almost as a routine measure. The treatment in this hospital has been almost entirely conservative and the results appear to be satisfactory.

All the patients with retained foreign body in the chest treated in this hospital are not reported, as many were in transit to southern hospitals and were not under observation for a sufficiently long period to enable the adoption of a definite line of treatment. The cases reported comprise the entire series of patients admitted over a period of three months and whose stay in hospital exceeded seven days. They are typical of all the cases treated in this hospital. Generally immediate treatment had been carried out before admission and this is really a report of the late management of these cases. The discussion will be divided into four sections: (a) general outline of treatment; (b) management of penetrating wounds; (c) management of perforating wounds; (d) discussion of different methods of treatment.

GENERAL OUTLINE OF TREATMENT.

All patients on admission were classified into one of three classes and treated accordingly.

Class I.

Patients with a positive pressure thorax comprised Class I. This condition was found to be due to one or a combination of the following causes: (i) "sucking" wounds, (ii) broncho-pleural fistula, (iii) the entry of fluid or air into the pleural cavity. The results of this positive pressure thorax are: mediastinal flutter, paradoxical respiration, compression of the sound lung by displacement of the mediastinum, haemorrhage, dyspnoea and cyanosis. In Cases XXIX and XVIII these symptoms were present on the patients' admission.

The treatment adopted was: (i) Immediate control of superficial "sucking" wounds. (ii) Aspiration of the pleural cavity. (iii) Relief of positive pressure pneumothorax by insertion of a needle or of an intercostal tube. In Case XXIX the patient suffered from a broncho-pleural fistula of valvular type, causing marked positive pressure with acute signs of mediastinal flutter. (iv) Application of a sponge rubber plug associated with a negative pressure suction bottle. This treatment was used in Case XVIII and in a modified form in Cases XXIX and XXXII. As both these patients suffered from broncho-pleural fistulae, the negative pressure could not be maintained for a lengthy period.

Class II.

Patients in whom there is already a negative pressure thorax comprised Class II. The object of treatment in these circumstances was twofold:

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(i) control and abolition of the pneumothorax, (ii) the establishment and maintenance of a "dry pleura". The term "dry pleura" is used in a surgical sense as half an ounce of drainage per day was treated as a normal transudate.

The therapeutic measures adopted to this end are as follows: (i) Aspiration of the pleural cavity. (ii) Intercostal drainage with the Malecot tube. This was inserted with a trocar and cannula, the cannula being big enough to pass a number 28 tube. The Malecot tube was connected to a negative pressure bottle. (iii) Rubber tube drainage with a tube of half-inch bore. The Malecot tube was found satisfactory only whilst the fluid aspirated was thin and provided the maintenance of negative pressure was not necessary for too long a period. Immediately the fluid became thick with pus the Malecot tube was replaced with a thick rubber tube (half-inch bore), and this was connected by pressure tubing to a negative pressure bottle. (iv) Thoracotomy with rib resection. The cases in which this was necessary will be reviewed separately.

Class III.

The patients in Class III include those in the convalescent stage. This class included those patients with a consistently dry pleura and lung more than three-quarters expanded. These patients were kept in hospital and given graduated lung exercises under the control of a physiotherapist and physical training in the later stages. This was maintained until the chest expansion was two inches or more and until radiological examination revealed full expansion of the lungs and complete or almost complete absorption of the thickened pleura.

Cases Reviewed.

This paper is based on the type of wounds and treatment carried out in forty cases.¹ The information studied has included the presence or absence of haemoptysis, the organisms present in the aspirated fluid and X-ray reports on the final results. The wounds in the series may be divided into two classes: penetrating (lodging) wounds, 28 cases; perforating (entrance and exit) wounds, 12 cases.

The treatment carried out may be summarized as follows:

Closure of "sucking" wounds	13 cases
Treatment by aspiration alone	10 cases
Treatment by rib resection	10 cases
Treatment by intercostal tube drainage without rib resection	7 cases
Treatment by negative pressure	7 cases
Treatment by negative pressure, which failed	3 cases
Treatment by removal of foreign body from chest wall, no other deliberate treatment being necessary	10 cases

MANAGEMENT OF PENETRATING WOUNDS.

Penetrating wounds, of which there are twenty-eight in the series, can be classified conveniently according to the final site of lodgment of the missile. The final site of lodgment was found to be of considerable importance, as it will be shown that intrapleural lodgment caused more morbidity than intrapulmonary lodgment. The differentiation of the twenty-eight cases is as follows:

Missile in lung tissue 9 cases
 Missile in pleural cavity 6 cases
 Missile in thoracic wall 16 cases

These figures include three cases in which there were fragments both in the lung and in the chest wall.

¹ The author's detailed table of the forty cases has been omitted in order to save space.—
EDITOR.

Missile Lodged in Lung Tissues.

Of the nine missiles lodged in the lung, two were coughed up, none was removed, and seven were left *in situ*. Of these only one caused symptoms, namely, a large metallic foreign body measuring 12·0 by 9·0 millimetres, lodging posteriorly in the right lung (Case III). In June, 1943, there were in this case considerable areas of pneumonitis in the right lung, but not definitely associated with the foreign body. One month later a fair degree of resolution had occurred and chest expansion was three inches.

The type of missile in the lung tissue varied, namely, single fragments in five cases, multiple fragments in one case, a whole bullet in one case and a fragmented bullet in two cases.

The size of the missiles varied. Of the single fragments, the largest measured 12·0 by 9·0 millimetres, and the average size was 6·0 millimetres. Two fragments were coughed up. The multiple fragments consisted of portions of a tin hat fragmented by a machine-gun bullet, the largest being about 6·0 millimetres. The single bullet was one of small calibre, about 0·25. Of the fragmented bullets, in one case the major part of a 0·25 calibre bullet was intrapulmonary, and in the other case only minor fragments remained along the track of a perforating bullet of which the calibre was again 0·25.

The treatment required in this series of cases was not radical. Four patients required no major treatment.

One patient (Case I) was treated by rib resection after two aspirations which yielded only a total of eight ounces. This was performed before admission to this hospital. The reason given was "congenitally narrow intercostal spaces". A Tudor Edwards tube was inserted and left in place for several days.

In the other case in which rib resection was required (Case XVI), intercostal drainage was again tried and failed. The reason given was "rib spaces too narrow". This patient had marked scoliosis, and the reason for operation was an infected haemothorax. It is interesting to note that the missile in this case was so small that it was coughed up. In both cases in which rib resection was required, the reason given was "congenitally narrow intercostal space", and one of the patients suffered from scoliosis which greatly exaggerated this narrowing. Negative pressure was finally necessary in this case (Case XVI) before full expansion could be obtained.

Three cases responded to aspiration treatment alone, the number of aspirations necessary being nine, two and five respectively. The case in which nine aspirations were required was Case III, previously mentioned (with a large intrapulmonary foreign body). No drastic treatment was required in this instance.

Missile Lodged in Pleural Cavity.

Six missiles are recorded as having lodged in the pleural cavity; of these two were left *in situ* and four were removed. Both the foreign bodies left *in situ* were bullets and both were of small calibre (0·25). These were the only two bullets in this series.

In one case (Case VIII) the bullet lodged in the left costo-phrenic angle and caused considerable pleural exudation. This patient was wounded on December 7, 1942, and six pleural aspirations were attempted by the end of the month without any large quantity of blood being obtained. After his admission to this hospital, a total of 87 ounces was removed in the first week. Negative pressure was established through a Malecot tube inserted intercostally and was maintained for five days. The patient rapidly recovered. The lungs are now fully expanded and the only remaining disability is some pleural thickening.

In the other case (Case IX) there was a definite haemothorax, 250 cubic centimetres of blood being aspirated upon the day of wounding and 38 ounces of sterile fluid being removed seven weeks later. This was followed by full expansion and complete recovery; and the bullet, originally in the apex of the lung, was discovered in the costo-phrenic angle after the second aspiration.

The four foreign bodies removed from the pleural cavity were all fragments of varying size and shape, although exact information is lacking, as the operations were performed prior to admission to this hospital. A brief outline of these cases is now given.

CASE X.—A small foreign body was removed from the pleural cavity eleven weeks after infliction of the wound. Nine aspirations, in which 255 ounces of fluid were obtained, and a rib resection with dependent drainage were first performed. These were without success, but after the removal of the foreign body a quick recovery occurred. A dry pleura and expanding lung were obtained within five weeks. The size of the foreign body is unknown, but the wound of entrance was small and punctate.

CASE XI.—The foreign body was removed seven weeks after infliction of the wound and after only one aspiration. There was a quick recovery.

CASE XVII.—The foreign body was apparently a large fragment and was removed from the pleural cavity ten weeks after infliction of the wound. Four aspirations were carried out, and in the last of these three and a half pints of thin pus were obtained. Intercostal drainage was then tried without success. Complete recovery followed the removal of the foreign body.

CASE XXIV.—In this case extensive trauma was done to the posterior thoracic wall by a large piece of shell casing. The foreign body was removed six weeks after infliction of the wound, and repeated drainage and aspirations of loculated pus were necessary. The lung is now fully expanded, but recovery is not complete.

From this series the following two inferences may be deduced: firstly, that an intrapleural foreign body is much more of an irritant than an intra-pulmonary one, and, secondly, that the smooth contour of a small calibre bullet does not cause so much irritation as a piece of shell or mortar casing.

Missile Lodged in Chest Wall.

Of the sixteen missiles lodged in the chest wall thirteen were removed either completely or in part, and in the remaining three cases no attempt at removal was made, as the foreign bodies appeared to be symptomless. The reason for the widespread removal of the foreign bodies from the chest wall appears to be twofold: firstly, the ease of access, and, secondly, the number of cases in which a wound was excised. In one case (Case XXXVIII) the attempt to remove the foreign body occasioned a "sucking" wound which caused considerable morbidity.

MANAGEMENT OF PERFORATING WOUNDS.

Of the twelve patients with perforating wounds, four required no major treatment to the lung or to the pleural cavity, but in eight cases aspiration or the establishment of a more permanent drainage was found to be necessary.

On examining the four patients who did not require major treatment it was found that in two cases (Cases XV and XXXI) closure of a "sucking" wound sufficed: both these wounds were the exit wounds. In Case VII there was no history of a "sucking" wound, but the wounds were excised and sutured. In Case XXVII no treatment was necessary. In these cases no accurate record of the missile is obtainable, but all the patients agree that it was probably a small calibre bullet.

The eight cases in which treatment was needed fall easily into three sections:

1. Cases in which only one aspiration was necessary. These include Cases XXIII, XXVIII and XXXVII. In the first two cases the wounds were excised and sutured. Case XXXV should really be included in this class. The patient had in the right paravertebral gutter a small symptomless collection of encysted fluid which was removed by aspiration, and then a Malecot intercostal tube was inserted. Little drainage was obtained, and it seemed certain that this procedure was not necessary. Complete recovery was obtained in all four cases.

2. Cases in which broncho-pleural fistula was present, namely, Cases XXIX, XXX and XXXII. In all three cases "sucking" wounds were present which recurred despite frequent attempts at suture. Chronic empyema developed in all cases, and in only one (Case XXX) was negative pressure successfully established; this followed spontaneous healing of the broncho-pleural fistula. The result in all three cases was less satisfactory than that obtained in the remainder of the series, and in only one (Case XXXII) is the lung fully expanded. In Case XXX the upper lobe of the damaged lung is still collapsed, but the cavity contains a negative pressure and reexpansion will probably occur. In Case XXIX uniform expansion is taking place and the lung is three-quarters expanded. In all cases the general condition is excellent and the pleural cavity is "dry".

3. Chronic empyema with major collapse of the lung and gross thickening of the pleura. This occurred in one case, namely, Case XX. This patient was completely cured by negative pressure drainage. A negative pressure of eight inches of mercury was maintained for a considerable period, and the final result was a "dry pleura" with a fully expanded lung.

Cases Reviewed.

Only one patient (Case VII) received his wound in the Middle East, and the other eleven were all wounded in New Guinea, apparently by small calibre bullets. It will be seen that the only lesions that failed to respond quickly to very simple procedures were the broncho-pleural fistulae in three cases and the chronic empyema (Case XX).

The three broncho-pleural fistulae were the only three such lesions in this series and were extremely troublesome. In each case a "sucking" wound developed and recurred after suture.

The inference appears to be that perforating gunshot wounds of the lung due to small calibre bullets respond quickly to treatment, provided a broncho-pleural fistula does not develop.

DISCUSSION OF TREATMENT.

Pleural Exudate.

Fluid was aspirated from the pleural cavities in twenty-six cases of the series.

In six instances the aspirated fluid was reported to contain pyogenic organisms. In all cases the predominating organism was *Staphylococcus aureus*, and in only one instance (Case XXIX) a haemolytic streptococcus was found associated with *Staphylococcus aureus*; this was one of the series of broncho-pleural fistulae.

The aspirated fluid was sterile in eleven cases, although in three cases colonies of *Staphylococcus aureus* were later grown from it; in one case the growth was associated with a haemolytic streptococcus.

In six of the series the only organisms present were non-pyogenic. The pus in this case was foul smelling and the organisms were *Bacillus subtilis* and Gram-negative diphtheroids. In three instances no attempt was made to grow a culture from the fluid or the result is unknown. As these were cases in which only a small number of aspirations were necessary, either the organisms were non-pyogenic or the fluid was sterile.

The early records are not sufficiently complete to allow adequate correlation of the relationship of haemothorax with production of pleural exudate, but frank blood or a high percentage of blood was present in the aspirated fluid in fifteen of the twenty-six cases in which fluid appeared.

The quantity of blood aspirated was not always recorded, but many large quantities of fluid were withdrawn. In Case X, 206 ounces were aspirated by

seven aspirations spread over eight days. The fluid was blood stained during the whole of this period; it later became purulent and rib resection was necessary. On the other hand, in Case VIII, one aspiration yielded 63 ounces and there was no history of blood-stained fluid having been obtained. In this case the irritant was possibly the retained intrapleural bullet.

In conclusion, it would seem that in the series under review infection has not been an important factor. The presence of a haemothorax or, as previously recorded, an intrapleural opaque foreign body appears to be a factor of major importance in stimulating the formation of pleural exudate. The liberal exhibition of sulphanilamide is probably a big factor in controlling the infection.

Hæmoptysis.

From the records available the value of hæmoptysis as an indication of the type of lung injury is difficult to assess. Hæmoptysis occurred in twenty-two of the cases under review. Eight of the twelve patients with perforating injuries gave a history of having coughed up blood, and fourteen of the twenty-eight with penetrating wounds gave a similar history. In one case (Case IV) the lung did not suffer penetration, the missile, a piece of shell fragment, being lodged in the chest wall. The hæmoptysis in this instance may have been due to secondary congestion without penetration.

The history of hæmoptysis appeared to be of little value as an indication of the severity of the subsequent morbidity. Six patients giving a history of hæmoptysis required no treatment, eight responded to aspiration alone, whilst four were treated by intercostal drainage and another four required rib resection.

General Review of Treatment.

Treatment will now be reviewed under the following headings: (*a*) control of "sucking" wounds, (*b*) aspiration of pleural exudate, (*c*) rib resection, (*d*) intercostal drainage, (*e*) negative pressure drainage, (*f*) lung exercises and physical training.

The information regarding the early administration of sulphanilamide is too scanty to be of any value.

Control of "Sucking" Wounds.—The necessity for the immediate closure of "sucking" wounds and for the establishment of a negative pressure in the pleural cavity needs no emphasis. Failure to maintain the closure occurred in five of the thirteen wounds treated by closure in this series.

The reason for these failures is obvious. In three cases (Cases XXIX, XXX and XXXII) broncho-pleural fistulae were present and the establishment of a negative pressure in the pleural cavity was impossible. In Case XXI there was apparently a local thoracic wall infection.

The fifth patient (Case XVIII) had a large supraclavicular defect which was difficult to suture. This wound had been packed with gauze, three large pieces of which had passed on different occasions into the pleural cavity. This occurred prior to the patient's admission to an Australian general hospital. They were removed months later in this hospital by the suction of the ordinary negative pressure bottle. The supraclavicular wound was covered with a sponge rubber pad. After the establishment of a negative intrapleural pressure and removal of the gauze the supraclavicular wound closed spontaneously. Rapid progress occurred and a "dry" pleural cavity with expanding lung was quickly obtained.

The reasons for the failure of the closure of the "sucking" wounds appear to be as follows: (i) A broncho-pleural fistula may be present. This was of course incompatible with the establishment of a negative pressure in the pleural cavity. (ii) The site of the wound may prevent easy closure (Case XVIII). (iii) Local infection of the chest wall may be present. In all cases adequate control was established by means of a large sponge rubber pad combined with dependent drainage.

Aspiration.—The value of aspiration needs no emphasis; in view of the importance of a persisting hæmorthorax in the production of morbidity, early and repeated aspiration appears indicated. In two cases under review a large quantity of blood was aspirated on the day on which the wound was inflicted. Aspiration was the only method of treatment adopted in 25% of the cases reviewed, and the number of aspirations required varied from one to nine.

Rib Resection.—The operation of rib resection was performed in ten cases of the series. In four of these the foreign body was removed from the pleural cavity as previously described.

In four cases (Cases I, XVI, XX and XL) rib resection was performed in the presence of signs of gross pleural infection and after failure to aspirate an appreciable quantity of pus. In Case XX the patient also suffered from a comminuted fracture of the ribs which required *débridement*. Rib resection was performed on the remaining two patients of this group for special reasons. In Case XXV the patient had an interlobar collection of pus which resisted aspiration by ordinary methods. In Case XXIX the patient had a perforating "sucking" wound which resisted closure. Rib resection was performed to supply dependent drainage. Intercostal drainage would probably have sufficed and would have been preferable, as it was found later to be a matter of extreme difficulty to make the thoracotomy wound airtight.

From the foregoing it will be seen that thoracotomy was indicated in two main types of lesion: (a) Retained intrapleural foreign body, often associated with extensive thoracic wall damage. (This class contains four cases.) (b) A gross pleural infection, when attempted aspiration of exudate had failed because of viscosity, loculation or the inaccessible position of the inflammatory exudate.

Preliminary intercostal drainage was attempted in only one of these cases (Case XL).

Intercostal Drainage.—Intercostal drainage was carried out in the treatment of seven patients, and the use of negative pressure was attempted in each instance. Failure to secure the maintenance of a closed pleural cavity occurred in the case of two patients, who were eventually shown to suffer from broncho-pleural fistulae. These two patients were then treated adequately with dependent drainage with a water-seal bottle until healing of the fistulae occurred.

The main indication for the insertion of an intercostal tube is the presence of a repeatedly recurring exudate requiring frequent aspirations. The method employed was to insert a Malecot tube by the trocar and cannula method; this was replaced after seven days by a wide bore (half inch diameter) thick walled rubber tube, without side holes. This tube allowed the free passage of thick pus and the maintenance of a satisfactory negative pressure. The persistent use of a Malecot tube was unsatisfactory, as blockage was a frequent occurrence. In two cases (Cases VI and XVIII) the negative pressure was maintained through an intercostal tube for a period of over five months. During a considerable part of this time quantities of pus, varying up to four ounces, were removed daily. The final result in both cases was excellent. The patients were kept dry and comfortable, they gained weight, and in both cases lung expansion is almost complete.

The only apparent disadvantage of a long maintained intercostal drainage is the development of a mild but painful periostitis of the adjacent ribs. The intercostal drainage was established in the posterior axillary line in the fifth, sixth or seventh intercostal space, according to the X-ray indications.

Negative Pressure Drainage.—Negative pressure drainage was found to be a useful adjunct in conditions which had resisted other methods of treat-

ment. In all cases in which a permanent pleural drainage was established in this hospital, an attempt was made to establish a closed pleural cavity by means of negative pressure drainage. The advantages of negative pressure drainage are obvious. They are, firstly, the maintenance of a continuously "dry" pleural cavity, and, secondly, the establishment of conditions favourable to lung expansion. The thoracic tube was rendered airtight by simple methods. In most cases strapping with "Elastoplast" was found to suffice, in others the wound was sealed with gauze soaked in "Mastisol", and in cases in which a large thoracic wall defect was present, a sponge rubber plug was used.

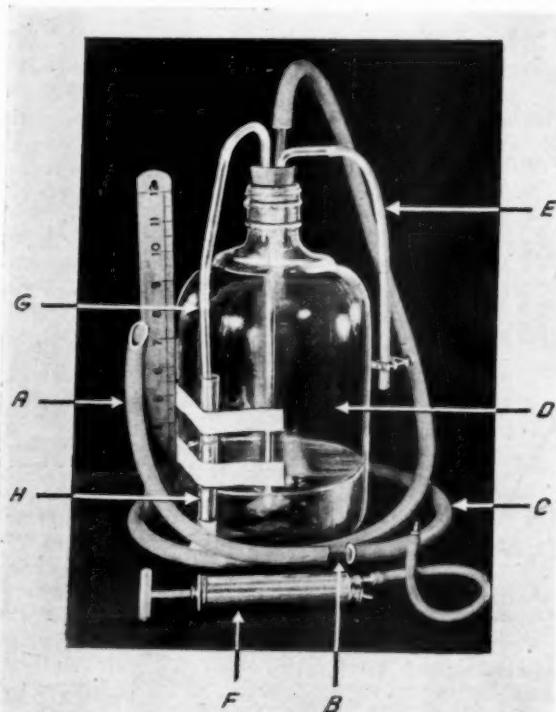


FIGURE I. Apparatus for maintenance of continuous pleural drainage. A: Wide bore firm rubber tube for insertion into pleural cavity. B: Glass connection. C: Pressure tubing. D: Large suction bottle with intake tube inserted below fluid level. E: Tubing controlled by screw clip for attachment to F. F: Potain's aspirator pump. G: Glass manometer tube inserted into mercury in test tube, H, for estimation of negative pressure. The relative size of the various parts is shown by the measure which is marked in inches.

three cases in which broncho-pleural fistulae were present. These patients were benefited, however, by the negative pressure drainage. Any collection of fluid was evacuated every four hours by the simple and convenient method of pumping the large bottle. In the remaining seven cases negative pressure therapy was uniformly successful. In three cases the intrathoracic tube was inserted through an intercostal space, and in four cases through a defect in the thoracic wall due either to a wound or a rib resection.

The suction bottle most suitable was a large, small-necked glass container (capacity about one gallon). The pressure was measured by a mercury manometer. The intrathoracic tube most suitable was a thick-walled, large-bore (half inch diameter) tube without side fenestration. This was connected to a suction bottle by means of pressure tubing. A small glass connexion was inserted to allow observation of the passage of pus. The negative pressure in the bottle was established by the use of a Potain's aspirator pump. The pressures found most useful were -4 inches of mercury, and in some cases with a considerable thickening of the pleura pressures of -8 inches of mercury were found necessary (see Figure I).

This method of drainage was attempted in ten cases; failure was recorded in the

In five of the seven cases in which negative pressure therapy was employed, permanent pleural drainage had been previously established without success. Consistent improvement immediately followed the use of negative pressure.

The criteria for the termination of negative pressure drainage are:

- (i) Daily pleural effusion obtained through drain should not exceed half an

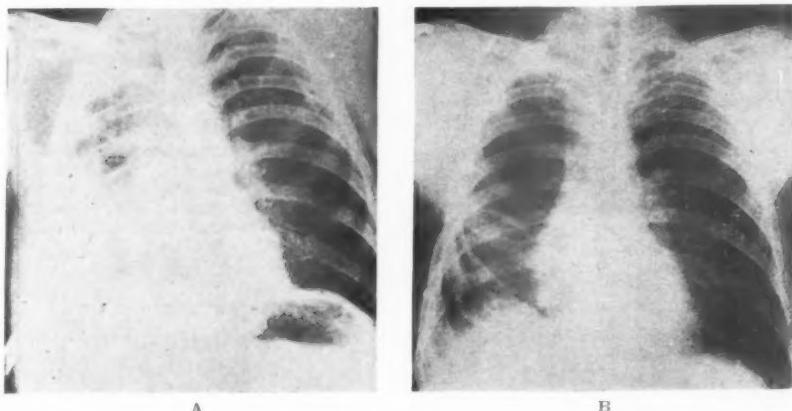


FIGURE II. Case XX. The first skiagram (A) shows the condition on February 8, 1943, at commencement of treatment by negative pressure drainage. The second skiagram (B) shows final condition just prior to discharge on August 17, 1943. The wounds were healed and the lung fully expanded. Chest expansion was three and a half inches.

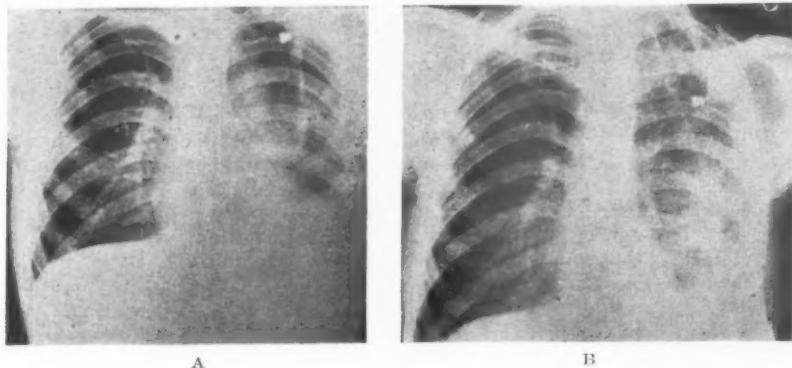


FIGURE III. Case XVIII. The first skiagram (A) shows condition at commencement of treatment on March 2, 1943. This patient made only slight progress because of the presence of three pieces of gauze in the pleural cavity. The second skiagram (B) shows the commencing expansion of lower lobe after removal of gauze by the suction bottle, August 5, 1943.

ounce. (ii) Radiological examination, repeated after fourteen days, should show an expanding lung. The lung should be at least 75% expanded or the lower lobe should be expanded to such an extent as to prevent the entrance of air into the pleural cavity.

Negative pressure was carried out for varying periods. In two cases (Cases VI and XVIII) the period exceeded five months. Usually, however, a period of from nine to twenty-one days sufficed.

The value of negative pressure therapy is illustrated in the following cases.

CASE XX.—This patient suffered a perforating gunshot wound on October 21, 1942. Considerable trauma was done to the thoracic wall, and after the failure of aspiration a rib resection was performed on December 1, 1942. The patient arrived in this hospital with the affected lung one-third collapsed, with the pleura greatly thickened, with the mediastinum grossly displaced and with a profuse purulent discharge. Negative pressure was established and maintained for sixteen weeks. The maximum pressure, which was maintained for half the period, was -8 inches of mercury. On April 14, 1943, expansion of the lung was complete and the patient's general condition was satisfactory (see Figure II).

CASE XVIII.—The patient was wounded on October 31, 1942. The lesion in this case was a penetrating wound of the left thorax due to a shell fragment, with a persistent supraclavicular "sucking" wound. An intercostal tube was inserted on November 10, 1942, and three pints of blood-stained fluid were evacuated. On March 3, 1943, continuous negative pressure of -4 inches of mercury was established. On June 28, 1943, three large pieces of gauze which, prior to admission to this hospital, had passed into the pleural cavity from dressings packed into the upper "sucking" wound, were "sucked" into the negative pressure tube and removed. Immediate improvement followed and negative pressure was discontinued on August 15, 1943 (see Figure III).

Lung Exercises and Physical Training (see Appendix).—After the condition of a "dry" pleura and expanding lung is obtained, the patient is given a continuous and graduated course of lung exercises and physical training, specially devised to produce chest expansion. This is continued until chest expansion exceeds two inches. It was particularly noticed that thickening of the visceral pleura gradually disappeared during this stage. Chest expansions of three and a half inches and four inches were regularly obtained.

Some of the patients on arrival at this hospital suffered from anaemia, debility and multiple "pressure sores". Great benefit in these cases was obtained from blood transfusion. One patient (Case XXIX) received three litres of blood in a period of forty-eight hours. This was followed by immediate and marked improvement.

RESULTS OF TREATMENT.

Results of the treatment were satisfactory. There were no deaths. In all but two cases (Cases XXIX and XXX) full expansion was obtained. These patients both suffered from broncho-pleural fistulae. In Case XXIX the patient was transferred to Melbourne with a rapidly expanding lung and in a greatly improved condition. In Case XXX the patient has a satisfactory chest expansion, the wound is healed, but full expansion of the upper left lobe is still resisted by a band of thickened pleura. As this cavity contains a negative pressure, final expansion is likely to occur.

GENERAL CONCLUSION.

The result of conservative therapy in the forty cases under review appears to be satisfactory, and the following deductions appear justifiable:

1. Indications for the removal of foreign bodies from the thorax may be summarized as follows. A small intrapulmonary metallic foreign body appears to cause little morbidity, and there appears to be no definite indication for removal of such foreign bodies. An intrapleural foreign body, on the other hand, appears to be a potent source of empyema. This is more suggestive when the foreign body is thick and jagged, and rapid cure of a pleural infection appears to follow removal of such foreign bodies. Foreign

bodies in the chest wall are frequently removed, and care must be taken as the attempted removal may cause a "sucking" wound, as in Case XXXVIII.

2. Perforating wounds resulting from a small calibre bullet do not appear to cause severe morbidity except when they produce broncho-pleural fistulae. Of the patients in this review suffering from perforating chest wounds, 25% developed a broncho-pleural fistula, which was the most difficult of all complications to correct.

3. Pleural effusion was present in the majority of the cases reviewed and the presence of a hemothorax played a prominent part in the development and maintenance of this pleural effusion. Infection was not a serious complication.

4. Haemoptysis was of not much value as an indication either of the nature of the wound or of the degree of morbidity to be expected.

5. The object of the treatment in the cases under review was to close the thorax, remove any effusion, establish a negative pressure in the pleural cavity and, if necessary, to remove any foreign body from the pleural cavity. Once the condition of a "dry" pleural cavity and an expanding lung was obtained, full expansion of the thorax was encouraged by lung exercises and physical training. Blood transfusion was given to debilitated patients.

6. The principal indication for intercostal drainage was the presence of a repeatedly recurring exudate requiring frequent aspiration. An attempt was made in every case to combine the use of an intercostal tube with negative pressure drainage.

7. Thoracotomy was performed in the series under review for two types of conditions: (a) retained intrapleural foreign body, (b) gross pleural infection which failed to respond to intercostal drainage.

SUMMARY.

1. Forty cases of gunshot wounds of the chest in patients treated at an Australian general hospital and the results obtained are reviewed.

2. The morbidity following penetrating and perforating wounds of the chest is discussed and a comparison is made.

3. A conservative scheme of treatment is outlined and the results of the various methods employed are reviewed.

ACKNOWLEDGEMENTS.

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APPENDIX.

Special Exercises Designed to Increase Chest Expansion.

A. Breathing Exercises.

Group I—On plinth, patient half-sitting propped with pillows.

1. Patient expires slowly without previous inspiration, saying the alphabet three times.
2. Unilateral costal breathing. Patient places hand on ribs of affected side. The other hand is placed on nostril of sound side. Pressure is given by physiotherapist on unaffected side—a short sharp inspiration with slow expiration six times.
3. Apical inspiration and expiration six to nine times.
4. Abdominal inspiration, contraction pushing chest wall well up—expiration slowly six to nine times.
5. Five short inspirations using muscles of upper chest and neck only. Expiration six to nine times.

Group II—Lying.

1. Legs and body bent towards sound side ("Whiting position"), arm raising above the head with breathing.
2. Lying with hands behind neck, knees flexed, head and shoulder raising with inspiration.
3. Legs straight, hands by sides, leg raising and inspiration, leg lowering and expiration.
4. Touching toes with breathing.
5. Side lying over pillow, arm raising with breathing—lying on sound side.
6. Side lying, arm stretching up and leg stretching down with breathing.
7. Apical breathing, three short inspirations followed by full expiration—four times.

Group III—Sitting.

1. Relaxed expiration (flow forward).
2. Hands on chest, flinging outwards with quick inspiration, slow expiration back to position.
3. Trunk flexion to side away from wound with inspiration, rise to sitting position with expiration.

Group IV—Standing.

1. Feet astride, hands above the head, relaxed expiration with hand flinging between the legs.
2. Running on the spot. The pulse can be taken before running on the spot, then immediately after the patient lies down, and again after two minutes, when it should have returned to normal.

B. Physical Training.

Lying.

1. Alternate leg raising.
2. Both legs raising.
3. Touching toes.
4. Ankle grasp, touching knees with the head.
5. Bicycling till breathless.
6. Neck rest, two arm rolling with chest lifting.
7. Alternate hip updrawing—really marking time with stiff knees. To be done quickly twelve times.
8. Alternate hand down, stretching sideways to touch knees. To be done quickly twelve times.
9. "Scissors." Quick alternate crossing and uncrossing of legs, leg raising up and over the head.

Lying Prone.

1. Alternate leg raising.
2. Both legs raising.
3. Shoulder raising.

Sitting on Plinth with Feet Fixed.

1. Arm throwing from one side to the other and shoulder turning.
2. Quick alternate side flexion.
3. Quick alternate side trunk rotation.
4. Trunk circling.
5. Shoulder turning with arm flinging around.
6. Head turning eight to ten times.

Standing.

1. Touching toes.
2. Arms circling.
3. Knees bending.
4. Sawing (punching forward with trunk flexion).
5. Alternate toe touching.
6. Running on the spot (thirty seconds to two minutes).
7. Skipping.

Deep breathing should be given frequently with these exercises. No strenuous physical training (and then only graduated) to be done until the above movements are completely free of pain.

TRAUMATIC RUPTURE OF THE URETHRA AND BLADDER.¹

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RUPTURE of the lower portion of the urinary tract is a comparatively rare condition and few large series of cases have been reported (Kidd,⁽¹⁾ Berry,⁽²⁾ Smith and Mintz,⁽³⁾ Moore,⁽⁴⁾ Harrison,⁽⁵⁾ Culver,⁽⁶⁾ Wheeler,⁽⁷⁾ Campbell,⁽⁸⁾ Bacon,⁽⁹⁾ and Culp⁽¹⁰⁾). Furthermore, the acute lesions in these reported cases have been seen and treated by many different surgeons. As a consequence no single method has had an extended trial, considerable controversy still exists, and the end-results remain generally unsatisfactory. In no surgical condition is prevention more important than cure. Many of the tragedies are caused by mismanagement in the first few hours. They belong to the realm of accident surgery and can be referred to genito-urinary specialists only when the initial but all-important operation is over. Consequently preference must be given to simple and safe methods of early management, and it is this aspect of the problem in particular that will be discussed in this paper.

The great majority of traumatic lesions of the lower portion of the urinary tract fall into three distinct groups which it is useful to examine separately: (i) rupture of the anterior portion of the urethra, (*a*) incomplete, (*b*) complete; (ii) rupture of the posterior portion of the urethra, (*a*) incomplete, (*b*) complete; (iii) rupture of the bladder, (*a*) extraperitoneal, (*b*) intraperitoneal. The posterior portion of the urethra includes the whole area beyond the bulb to the bladder neck. Penetrating injuries due to missiles of war⁽¹¹⁾ obviously will not conform to such a classification, but they can be investigated and treated on the same principles which underlie the management of civil injuries.

The anterior portion of the urethra is ruptured by direct violence and usually it is the bulb which is injured as it is crushed against the pubic arch. The lesion is often diffuse and the periurethral tissues are pulped. The second group is associated with a fractured pelvis and caused by indirect violence. The lesion is more circumscribed, but there is often wide separation. This difference has an important bearing on treatment, essentially the avoidance of residual stricture. In the first group it is minimized by placing the bruised tissues at rest and avoiding infection. In the second the chief problem is the immobilization of the fracture and the restoration of the soft parts. Three personal cases illustrating these types have already been reported (Barry⁽¹²⁾). Traumatic rupture of the bladder also is usually a complication of a fractured pelvis. A distended bladder, however, may be ruptured by direct trauma alone. Two examples are described later.

RUPTURE OF THE ANTERIOR PORTION OF THE URETHRA.

The common accident in this group is a fall astride or a blow on the perineum. The female urethra, being loosely attached to the anterior wall of the vagina, is very rarely injured. The numerous lesions caused by surgical instrumentation are not considered here.

The presenting signs are bleeding from the external meatus, bruising in the perineum and retention of urine. The degree of shock depends on the

¹ Accepted for publication on April 13, 1944.

severity of the accident, but it is seldom as severe as in the other groups associated with a fractured pelvis. The diagnosis is made from a correlation of the history and these signs. It is quite unnecessary to pass a catheter to confirm it. It may be impossible, however, to assess the extent of the lesion. The urethra may be contused without actual laceration, and if it is lacerated there may be a partial tear or complete separation.

The prognosis is determined by the amount of scar tissue formed in and around the urethra. All complications depend on the residual urethral stricture and its sequelæ: periurethral abscess, urinary fistulæ, urinary infection and calculus formation, chordee, sterility and impotence. Some scarring is inevitable and is dependent on the extent of the original lesion. Every effort must be made to keep it at a minimum by avoiding further trauma and rigidly precluding infection. To pass a catheter when the mucosa is swollen, bruised and lacerated augments one and invites the other.

In the typical crush injuries of the bulb spasm of the sphincter is always present and extravasation of urine does not occur for several hours.¹²⁰ Localized blows to the distal end of the penis, however, may cause slight bleeding without retention. If the patient passes a normal stream of urine no special treatment is necessary. He should be given a course of sulphonamide, kept under observation and any sign of infection, extravasation or difficulty in micturition should be noted. Two such cases were seen in the early months of the war and both patients recovered without any interference. The numerous minor lesions due to instrumentation belong to the same category.

In all other cases the bladder must be drained by immediate suprapubic cystotomy. Perineal section has been used as a routine by some surgeons (Berry,¹²¹ Culver,¹²² Turner¹²³). It results in an additional lesion to the urethra and is an operation with which the casualty surgeon is usually not familiar. By suprapubic cystotomy the urine is diverted before extravasation can occur and the bruised tissues are left undisturbed and uninjected until all swelling has subsided.

In many cases this is all that is necessary. But where the damage is more extensive as shown by a large perineal haematoma and in late cases where extravasation is suspected, it is necessary to combine suprapubic cystotomy with perineal drainage. This also enables one to see whether the rupture is complete and to unite the divided ends if separation has occurred. The tissues are bruised and it may be difficult to identify the proximal end of the urethra. Many suggestions have been made to find it, but the most practical method is to pass a retrograde catheter through the suprapubic incision. If the catheter is removed at the end of the operation, it will cause less damage than prolonged exploration by the surgeon in an oedematous field. In ideal cases the rupture may be closed by end-to-end suture at this stage, but whenever there is any tension or infection only the roof should be sutured. This can best be done by two or three mattress sutures of plain catgut and the perineal wound left wide open.¹²⁴ Early suture as described is not essential in this type of rupture. Provided the urine is short-circuited even a complete rupture may well be left for a week until more skilled surgical aid is available.¹²⁵ When swelling has subsided and the wound is healing a catheter may be passed to keep the lumen open. Suprapubic drainage must be maintained till the perineal wound has completely healed and any stricture is fully dilated. In most cases, even though the patients are free from symptoms, well marked scarring will be found on urethroscopic examination (Kidd¹²⁶). This should never be neglected. Regular dilatation is needed; in some cases for a few months only, in many at intervals for life.

One personal case in a boy, aged eleven years, was treated with an indwelling catheter (following orthodox teaching). He had slipped when climbing over a fence and fallen astride. He had a few drops of blood at his external meatus, retention of

urine and a small perineal haematoma near the bulb. Drainage of the bladder was never satisfactory; urine trickled down the side of the catheter and the haematoma soon became infected. Before it was realized that a perineal abscess was developing an inch of urethra had sloughed—a life-long tragedy in a small boy.

The fact that an indwelling catheter has given satisfactory results in some hands is no real argument. It is quite unnecessary in treating ruptures of this type; its use increases the residual stricture and entails a constant risk of precipitating further complications (Smith and Mintz,⁶³ Campbell,⁶⁴ Marion,⁶⁵ Hamilton Bailey,⁶⁶ Morson⁶⁷).

RUPTURE OF THE POSTERIOR PORTION OF THE URETHRA.

The incidence of injury to the urinary tract associated with fractures of the pelvis is uncertain, but it is probably not more than 5%.^{68,69} It depends on the site of the fracture and the degree of displacement. One must suspect it when separation of the symphysis or fracture of the pubic rami is present and especially in cases of complete fracture dislocation of the pelvic girdle. The urethra may be torn where it is held fixed by the membranous sphincter and either the bladder or urethra may be pierced by sharp fragments of bone. When the pelvis has been laterally compressed and its antero-posterior diameter increased, the pubo-prostatic ligaments may be torn, and as blood and urine accumulate in the prevesical pouch the bladder and prostate are rotated upwards and backwards until there is often a gap of an inch or more between the torn ends of the urethra. In neglected cases the bladder becomes anchored in its new position and the gap between the torn ends is filled with fibrous tissue. Any late attempt at restoration has little hope of success.

In this type of rupture the injury is often so severe that it proves rapidly fatal. In others the patients are so shocked that they need full resuscitation before any operative interference can be attempted. The urinary lesion must always be considered with the fractured pelvis. Where bony displacement is present the sooner it is reduced, the better. Reduction prevents further haemorrhage and shock and may bring together the separated ends of a torn urethra. In any case, the pelvis must be immobilized. The pelvis can be controlled temporarily by a pelvic sling, but as soon as the bladder has been drained and the continuity of the urethra restored, it should be enclosed in a plaster spica. Room is easily left for the indwelling suprapubic catheter.⁶⁹ (See Figures II and IV.)

Diagnosis of intrapelvic rupture is not difficult provided the possibility is always kept in mind. Associated with a fractured pelvis there is tenderness and often dulness suprapubically. The patient is unable to pass water, and there may or may not be bleeding from the external meatus. It is impossible at this stage to distinguish between an intrapelvic rupture of the urethra and an extraperitoneal rupture of the bladder, but as the initial treatment is similar in each case the exact diagnosis is best left till the site is explored. A rectal examination may indicate that the prostate has been dislocated upwards.

If there is any doubt a catheter must be passed to exclude a rupture, as expectant treatment should never be adopted. When this is done the surgeon must bear in mind certain fallacies. Where there is a dislocation of the bladder neck the catheter will pass into the prevesical space, withdraw blood and urine and suggest that the urethral tract, though lacerated, is intact. Or it may pass through a rent in the bladder and withdraw urine from the peritoneal cavity. In addition, more than one lesion may be present. Unless a normal quantity of clear bloodless urine is withdrawn, the diagnosis of rupture of the urethra or bladder must be made. Accessory investigations (injection and withdrawal of known quantities of saline solution, retrograde and excretion cystograms, cystoscopy) are uncertain and unnecessary. They may increase

trauma and extravasation; they delay early operation and should be regarded as only of academic interest.

As soon as the patient is fit for operation a suprapubic incision is made and the site of the rupture explored. Owing to the extravasation of blood and urine into the extraperitoneal tissues, the normal structures may be difficult to identify. The bladder is opened and a urethral catheter is passed to ensure that the urethra is intact. If this passes into the bladder it is removed, a suprapubic self-retaining catheter is left in the bladder and the prevesical space is drained. Cases of incomplete intrapelvic rupture must be very rare.

One was seen in a despatch rider who crashed but managed to walk back to his unit. About an hour later he noticed blood dripping from his urethra and was unable to pass his water. On examination he was not shocked or in pain, but an X-ray examination revealed a fracture of the left pubic ramus, and the lower part of his abdomen was tender and dull to percussion. A soft rubber catheter was passed and withdrew urine and a little dark altered blood. The patient had, at operation, an extravasation of blood in the prevesical space, but an intact urethra and bladder. He was treated as outlined above and three weeks later his urethra was dilated up without difficulty and his de Pezzer catheter was removed. He developed a stricture of his membranous urethra which, though easily dilated, had a strong tendency to recur.

When the membrano-prostatic urethra has been completely torn across and the neck of the bladder has rotated backwards, the urethral catheter will be seen to pass into the prevesical space. Many methods have been described to approximate the divided ends of the urethra and to hold the bladder in its normal position. Probably the simplest and surest is to pass a sound *per urethram* till it emerges just above the membranous urethra. The index finger is then placed in the internal meatus and the base of the bladder is pushed down to the point of the sound. This is gently insinuated into the bladder and an indwelling catheter withdrawn.⁽⁵¹⁾⁽²⁰⁾ If there is still any tendency for the displacement to recur, some means of maintaining a constant pull on the base of the bladder must be devised. This has been achieved by attaching a rubber collar to the catheter,⁽²¹⁾ by means of a Foley's retention catheter,⁽²²⁾ or by using any of the inflatable bags used to control bleeding after prostatectomy. Slight tension is maintained by keeping the catheter strapped to the patient's leg.

Here, as with extrapelvic ruptures, an indwelling catheter is undesirable. However, the soft parts must be kept in position at all costs and there is often no alternative. It can be changed when necessary by the "railroad" method. When adequate facilities are available and the patient is fit to stand a long operation, the ideal method is direct suture of the ruptured urethra from a perineal approach (Smith and Mintz,⁽²³⁾ Young,⁽²⁴⁾ Deansley⁽²⁵⁾). A very successful case has been recently reported by Hunt and Morgan,⁽²⁶⁾ who used the lithotomy-Trendelenburg position with two surgeons working simultaneously, one from the abdomen and the other from the perineum as in the operation for combined abdomino-perineal resection for carcinoma of the rectum. Such facilities, though very desirable, are not often available to those dealing with accident surgery. In cases in which the early restoration of the urethra has been unsuccessful or neglected a urethro-cystogram may reveal a gap of an inch. Various attempts have been made to reconstruct the torn urethra, but control of the sphincter is usually lost. To avoid the permanent use of a urinal, transplantation of the ureters is left as a final hope.

One case of this type was seen in a seven-year-old boy knocked down by a lorry. He was extremely shocked on admission to hospital and showed signs of internal haemorrhage. He had not passed any water and there was no bleeding from his urethra. An X-ray examination revealed slight separation of his *symphysis pubis*. His abdomen was generally tender. A suprapubic incision revealed a large extravasation of blood in the prevesical space and extraperitoneal tissues extending to the umbilicus. The bladder was dislocated backwards, but still distended. A catheter was passed and entered the

prevesical space. It was introduced into the bladder by the manoeuvre outlined above and tied in. This child recovered, but when last seen about nine months after his accident had not regained control of his membranous sphincter.

Two other examples were seen recently at an Australian general hospital in New Guinea.

M., a native, aged twenty years, was admitted to hospital on April 9, 1944. Three hours earlier he had fallen off a trailer and its rear wheels had passed over him. He was severely shocked on admission, and the administration of a blood transfusion followed by plasma was begun. He had a tender suprapubic swelling, a lacerated scrotum, but no bleeding from the urethra. A catheter was passed and eight ounces of blood were withdrawn. The catheter did not appear to have entered the bladder and a pre-operative diagnosis of intrapelvic rupture of the urethra was made.

Four hours after admission the patient was considered fit for operation. A total of 0·6 gramme of "Pentothal" was introduced into the "intravenous plasma drip" and provided adequate anaesthesia. A mid-line suprapubic incision was made and revealed an extravasation of blood in the prevesical space and a comminuted fracture of both pubic rami. The bladder was dislocated backwards and when opened contained clear urine under moderate pressure. A urethral sound was passed, but was blocked at the base of the bladder. This was then opened and by the insertion of a finger into the internal meatus the sound was easily directed in. A de Pezzer catheter was tied to the tip of the sound, which was then withdrawn, a silkworm suture being left attached to the tip of the de Pezzer catheter and emerging from the suprapubic wound so as to facilitate its removal at a later date. The bladder was closed around a Malecot catheter and the prevesical space was drained. A radiograph subsequent to the application of a plaster spica showed comminuted fractures of pubis and ischium on both sides (see Figures I and II). The patient, after making a good recovery from his initial shock and operation, developed a pyrexia of 106° F. and died thirty-four hours after admission.

An Australian soldier, aged twenty-eight years, was pinned under a truck when it overturned. His pelvis was compressed from side to side and was only released four hours later with the help of chloroform. He was admitted to hospital on May 25, 1944, eight hours after the accident. He had attempted to pass urine, but was unable to do so. A soft rubber catheter passed easily, but withdrew only a few ounces of pure blood; and again the diagnosis of intrapelvic rupture of the urethra associated with a fractured pelvis was made.

He was given a blood transfusion, and under "Pentothal" anaesthesia the bladder was explored. There were widespread haemorrhage in the extraperitoneal tissues and a complete dislocation of the base of the bladder. After the performance of cystostomy a finger was placed in the internal meatus, but there was a gap of approximately two inches between the point where a urethral sound entered the pelvis and the apex of the prostate. On account of the posterior rotation of the base of the bladder and the interposition of torn prostatic capsule, it proved difficult to find the opening of the prostatic urethra with the tip of the urethral sound. It was facilitated by having an assistant's finger in the rectum and after further manipulation the sound was passed into the bladder and a de Pezzer catheter with rubber cuff was withdrawn. Continuous traction was maintained to the penile end to hold the soft tissues in apposition. The bladder and prevesical space were drained as usual and the pelvis was immobilized in a plaster spica at the conclusion of the operation.

The patient's condition improved rapidly. Urethral traction was painful and was released after seven hours. Five days later the de Pezzer catheter and rubber cuff were withdrawn and replaced by a soft rubber catheter introduced by the "railroad" method. After a week the plaster spica, which had greatly facilitated the nursing of this patient, was changed and he was considered fit for evacuation to base (see Figures III and IV).

The autopsy on the native provided an opportunity for a critical examination of the lesion itself, the effectiveness of a self-retaining catheter as introduced by the method described above in restoring the soft parts and the possibilities and problems of direct suture of the urethra at this site.

The body was placed in the lithotomy position and through a curved incision in front of the anus the rectovesical space was opened. The catheter was *in situ* and when slight traction was applied to its distal end it maintained the urethra and soft parts in complete alignment. When it was removed the prostate was seen lying quite free and there was a complete transverse rupture of the urethra between the apex of the prostate and the urogenital diaphragm. The membranous urethra was then mobilized by dividing the attachments of the urogenital diaphragm to the ischiopubic rami, after which an end-to-end suture of the urethra was readily accomplished (Hunt and Morgan⁽²⁾).

Such an operation introduces further risk in a shocked patient with a fractured pelvis and often other concomitant injuries. Though quite feasible when adequate facilities are available, it appeared to have no advantage over the much simpler manoeuvre of introducing a self-retaining catheter. The



FIGURE I. Radiograph of native with fractured pelvis and complete rupture of the posterior urethra showing self-retaining urethral and suprapubic catheters *in situ*.

prostatic sphincter in this injury is not damaged. The bladder in these three personal cases was distended with clear urine at operation. There seems little hope of accurately repairing a torn membranous sphincter, even after perineal exposure, whereas there is always a risk of further damaging its musculature and nerve supply. Moreover, the results of perineal prostatectomy provided ample proof that an indwelling catheter can restore full function provided the membranous sphincter is intact.

RUPTURE OF THE BLADDER.

Apart from the penetrating injuries of war, the bladder is usually injured as a complication of



FIGURE II. Photograph from same case as shown in Figure I, showing management in plaster spica.

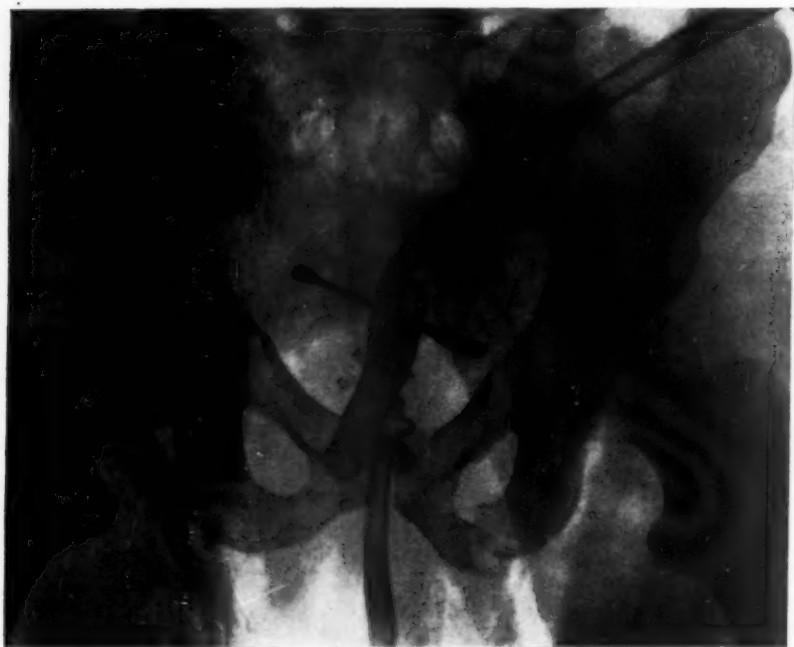


FIGURE III. Radiograph through plaster cast showing fractures of superior and inferior rami of right and left pubis. The de Pezzer catheter in the urethra with its cuff at the internal meatus together with the suprapubic cystostomy catheter and the prevesical drainage tube are also shown.

a fractured pelvis or a fall on the abdomen when the organ is distended. Cases of spontaneous rupture have been recorded, but with few exceptions there has been some coexistent disease—malignant ulceration, inflammatory spread, degenerative changes from chronic distension, *tabes dorsalis*. In some the possibility of direct trauma cannot be eliminated. It is a well recognized complication of herniotomy, of operations in the pelvis and especially of those through the urethra. Bacon,¹⁰ in an analysis of 147 cases, found 40 due to transurethral instrumentation. As an accident in healthy patients rupture of the bladder is quite rare. The vulnerability of the bladder is in direct proportion to its distension, and probably a third of all cases of rupture are associated with alcoholism. Here the bladder is full, accidents are frequent and trauma is often unrecognized.

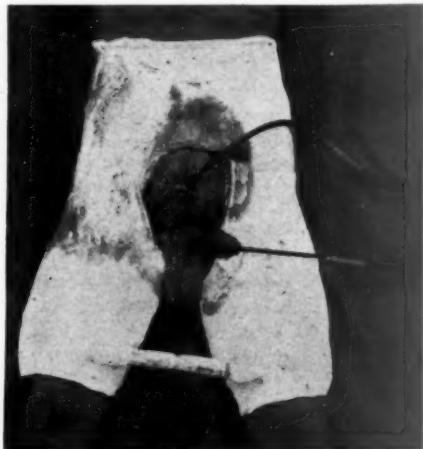


FIGURE IV. Photograph of patient whose radiograph is reproduced in Figure III, showing management in plaster spica.

The lesion may be extraperitoneal, intraperitoneal or both. Two-thirds of the ruptures are said to be intraperitoneal⁽²⁰⁾ and the mortality in these is higher than in extraperitoneal cases. The mortality is still very high—approximately 50%^(20,21)—but depends on the severity of the accident, associated injuries and the time which elapses before the bladder is drained.⁽²⁰⁾ Many patients are lost because the diagnosis is not made early enough.

In any case of fractured pelvis or when there is a history of a fall on the abdomen (and especially in an alcoholic) the possibility of rupture of the bladder must be considered. In gunshot wounds any potential site of entry of a missile is suspect, especially wounds of the buttock. It is important to inquire when the bladder was last emptied. The patient usually complains that he cannot pass water, but he may have lost the desire to do so. He is shocked and complains of abdominal pain. When there is the slightest doubt a catheter must be passed, and unless clear urine, free from blood, is withdrawn, the diagnosis is made. Often only a few cubic centimetres of blood and urine will be obtained. As with intrapelvic ruptures of the urethra, the exact diagnosis is not necessary and accessory investigations must not divert the surgeon from his only safe course—an immediate exploratory suprapubic incision.

Once this has been made an extraperitoneal rupture becomes obvious, for there is widespread extravasation of blood and urine. Cystotomy is performed and a finger is introduced into the bladder to exclude any intraperitoneal lesion. If there is any doubt at all, and especially in penetrating injuries of warfare, the peritoneal cavity should be opened and closed immediately if there is no free fluid present. Nothing more is necessary than to close the bladder around the suprapubic tube and drain the cave of Retzius.

If there is no extraperitoneal rupture, the peritoneum is opened and the diagnosis of intraperitoneal rupture is confirmed by finding urine. The anterior wall of the bladder is then opened extraperitoneally for drainage and the rent in the vault is closed either from the peritoneal cavity or from within the bladder. Provided free suprapubic drainage is instituted no elaborate closure of the rupture is necessary. The peritoneal cavity is drained for twenty-four hours, the prevesical space a little longer, and the cystostomy opening is maintained for approximately a fortnight.

In the case of gunshot wounds one must always remember that the bladder is rarely injured alone and injury to abdominal viscera must be excluded. When there has been extensive trauma to the base, and especially is this true in cases seen late, the pelvic cellular spaces may need further drainage. This is best obtained through a curved incision in front of the anus (Macalpine⁽²²⁾), and it should be used in addition to suprapubic cystotomy and drainage of the prevesical space from above. In such cases transplantation of a ureter may be necessary. A course of sulphonamide or penicillin should be prescribed.

The following two cases represent the typical findings in uncomplicated extraperitoneal and intraperitoneal lesions and they illustrate the value of early suprapubic drainage.

J.N., a soldier, aged thirty-nine years, was admitted to Southend General Hospital on April 7, 1940. Twelve hours previously, while on embarkation leave and enjoying a party with his friends, he fell down twenty-four stairs. He had not passed water since, but complained of an intense pain across the lower part of his abdomen. There was no bleeding from the urethra or bruising in the perineum. His lower abdominal segment was tender and rigid. An X-ray examination revealed no fracture of the pelvis. A catheter passed in the casualty room on admission withdrew six ounces of urine with a sediment of dark altered blood.

An immediate lower mid-line incision revealed the extraperitoneal tissues widely infiltrated with blood and urine, and the bladder wall was thick and oedematous. The

peritoneal cavity was opened to exclude any intraperitoneal lesion, and immediately closed. A suprapubic cystostomy was performed, a de Pezzer catheter was tied in and the prevesical space drained. The patient recovered well, and a fortnight later a urethral catheter was passed. Four weeks after his accident his suprapubic wound had healed soundly and he was discharged fit.

R.G., aged forty-three years, was admitted to the London Hospital on June 4, 1941, complaining of abdominal pain and inability to pass water. The previous night he had had a few drinks with his friends before retiring to bed. At 2 a.m., when getting out of his bunk in an air raid shelter to pass water, he fell six feet and struck his abdomen on a low form. He was brought straight to hospital; but, as he could walk normally in the receiving room and there was no definite abdominal tenderness, no serious injury was suspected, and he was allowed to go home. He returned four hours later with increasing abdominal pain. He had not passed water since 10 o'clock the previous night. There was no history of any previous urinary trouble.

On examination he appeared shocked and in pain. There was a slight fullness in his right iliac fossa and his abdomen was tender and rigid. Intestinal sounds were few but audible. The bladder was not palpable. There was no bleeding from the urethra. A soft rubber catheter was passed and an ounce of blood-stained urine withdrawn.

A lower mid-line incision was made and his bladder exposed. It was collapsed, and there was no extraperitoneal extravasation. The anterior wall of the bladder was then opened, and a linear ragged tear four inches long was seen on the posterior wall below the fundus. This was closed from within the bladder with interrupted plain catgut stitches. The peritoneal reflection was then opened, and a large quantity of urine drained from the peritoneal cavity. A Malecot catheter was tied into the bladder and the peritoneal cavity was drained for twenty-four hours. A fortnight later the Malecot catheter was removed, and the patient passed some urine naturally. One week later the suprapubic wound was dry, and the same day, to demonstrate his recovery to the ward, the patient passed 236 ounces of urine—nearly 12 pints.

SUMMARY.

Traumatic rupture of the lower portion of the urinary tract has been discussed under three groups: the anterior or extrapelvic section of the urethra, the posterior or intrapelvic section of the urethra, the urinary bladder.

The essential points in diagnosis and a simple method of emergency treatment have been described for each group.

The importance of immediate suprapubic drainage, the pitfalls of an indwelling catheter, and the need for early restoration of the soft parts in intrapelvic rupture have been stressed.

Personal cases illustrating each type are reported.

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A METHOD OF TREATMENT OF COMPOUND FRACTURES OF THE HUMERUS.¹

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GUNSHOT wounds of the extremities involve two problems—the immobilization of the fracture, and the management of the soft tissue wound—and it is frequently difficult to reconcile the requirements of each of these, especially in the case of the arm. The common picture presented in gunshot wounds of the humerus, as seen in hospital, is one of gross comminution, often with considerable bone destruction, established sepsis and various grades of skin and soft tissue loss, with as a rule involvement of the shoulder or elbow joints.

The primary aim in treatment is to establish at the earliest possible time a mode of fixation which can be retained continuously and without interference until sepsis is fully controlled and healing is proceeding, since any manipulation prior to this will almost certainly provoke systemic reaction as well as delay local reparative processes. Fixation of the humerus is notoriously difficult to achieve, and it is probably impossible to attain anything like satisfactory immobilization unless the trunk is included in the fixing mechanism. Plaster of Paris spicas are, therefore, commonly used in the treatment of these fractures; but when applied as complete casts they suffer from the disadvantage of requiring renewal at intervals, whenever there is any considerable amount of discharge, which is the usual state of affairs.

A pus-soaked cast is uncomfortable and offensive, and not only invites superadded infection but menaces other wounds in a ward. If, however, access to the wound is provided, these difficulties do not exist, and the cast can be retained for an indefinite period, allowing the fixation to be continuous. Access provides the following advantages:

1. Soft tissue wounds can be managed by established methods of non-traumatic dressing, with the use of specific local therapy for control of infection—for example, sulphonamides, acridines, penicillin *et cetera*—under full bacteriological control.
2. Where pressure is indicated this can be applied by suitable bandages or other means.
3. Small skin grafts and minor sequestrectomies can be carried out without disturbance of the fracture.

It thus becomes feasible to manage these wounds by the methods at present in use for treating uncomplicated soft tissue injuries, which constitute a positive attempt to combat infection and permit spontaneous healing to occur in the shortest possible time, or alternatively to prepare the way for secondary surgical procedures—for example, grafting.

In an attempt to satisfy the conflicting requirements of wound management and continuous immobilization the following method has been adopted:

1. A body cast is first applied.
2. This extends below the iliac crests—an important point for comfort—and over both shoulders. Occasionally the bridge over the affected shoulder has to be very narrow to avoid the wound. On the other hand, when the wound is well below the shoulder the cast is carried down the arm as a sleeve to just above the wound.

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3. A forearm cast is then made, extending from just proximal to the metacarpo-phalangeal joints, allowing full flexion of these joints, to a point below the lower limit of the wound. This cast encircles the forearm and as a rule a variable portion of the lower arm.

4. The arm is then "lined up" in the desired position and the forearm cast is bridged to the body cast with plaster of Paris "rope" or Cramer wire wound with plaster of Paris bandages. Two such bridges in different planes provide great strength. It has been found convenient to carry a Cramer wire bridge from the region of the iliac crest to a point below the mid-forearm and a "rope" from just in front of the shoulder to the inner edge of the forearm cast just above the wrist.

5. Iliac crests, shoulders and bony prominences around the elbow are carefully padded with felt. Felt rings are also placed around the arm where the plaster ends, above and below the wound.

6. Further protection of the cast may be obtained by surrounding the area of the wound with a sleeve of thin waterproof material which is glued or strapped onto the arm. When the cast is completed this sleeve is cut in a circular fashion and the ends turned back over the plaster edges and fixed with a turn of plaster of Paris bandage.



FIGURE I. Case I illustrates external bridge and rubber sling to correct medial bowing.



FIGURE II. Case II shows leather finger collars attached by rubber bands to hooks incorporated in the dorsal surface of the forearm plaster, allowing active flexion against elastic extension.

Casts made in this way have been worn for periods up to four and a half months without any deterioration. Despite the appearance of bulk, the patients have found them extremely comfortable, and a considerable degree of activity is permitted. On several occasions small skin grafts have been performed without difficulty, and the fixation of the limb has assisted materially in securing a "take".

In Case I the unsupported segment tended to sag medially. A lateral Cramer wire bridge from shoulder to elbow provided a point of attachment for a rubber sling placed around the fracture site; the displacement was easily corrected by this means (Figure I).

In Case II there was an associated radial nerve lesion. Wire hooks were incorporated in the dorsal surface of the forearm plaster, and to these were attached the rubber bands and leather finger collars which constitute the distal portion of a radial nerve splint, active use of the flexors against elastic extension being allowed (Figure II).

Case III illustrates an adaptation of the method to meet another problem. This patient had an ununited fracture of the humerus for which bone grafting was proposed and immediate post-operative fixation was required. Application



FIGURE III. Case III shows two sections of the prefabricated cast.

of a spica under anaesthesia would obviously have been extremely difficult, and a cast was therefore prefabricated in the following manner:

1. Body plaster. When half the thickness was applied, wooden pegs with a nail in the centre and one half of peg greased, were placed one over each shoulder and three on each side of the trunk in the mid-axillary line. Plaster of Paris bandaging was then continued (the nails easily penetrated the bandages so that on completion of the plaster a line of section was provided). The cast was then bisected, the portion deep to pegs being cut away with a curved knife, and the two sections easily separated (Figure III), the ungreased portions of pegs remaining fixed in plaster and the greased portions easily lifting out. Webbing and buckles were then fixed around the trunk and over the shoulders and the cast was allowed to harden.



FIGURE IV. Case III illustrates the cast assembled.

turned onto the sound side, and forearm and arm were bandaged into the cast (Figure V).

CASE I.—L.J.L. received a gunshot wound of the right shoulder on August 14, 1943. There was a grossly comminuted fracture of the proximal half of the humerus, involving

The two sections of the cast were applied at the conclusion of the operation with the patient

the head, half of which was dislocated medially. The patient was admitted to hospital on October 8, 1943, in complete plaster of Paris spica including arm and forearm. His general condition was very poor. Pus was soaking through the plaster. Removal of the plaster disclosed large wounds on the anterior aspect of the shoulder and the outer surface of the upper part of the arm, and a small wound of the middle of the inner surface of the arm; all were discharging copiously. The fracture was quite loose.

Despite application of a large "Cockle" plaster and transfusion, his general condition remained unsatisfactory and nursing proved very difficult. On November 19, 1943, the condition of the wounds and of the fracture was unchanged, and the patient was miserable and depressed. A cast such as described was then applied, and thereafter there was no further discomfort, nursing became simple and progress was uninterrupted. The wounds were dressed atraumatically by the sulphanilamide powder-tulle *gras*-saline method (culture showed presence of *Streptococcus pyogenes*) and were healed by January 24, 1944.

The cast was finally removed on March 12, 1944, when handling of the fracture had suggested union, and this was confirmed clinically and radiologically.

CASE II.—P.G. sustained a gunshot wound of the left arm on October 5, 1943. There was a compound comminuted fracture of the humerus with considerable bone loss. Radial and median nerve lesions were present, the latter incomplete. A blood transfusion was given and primary excision of wounds was carried out. A cast was applied on November 26, 1943, and the distal portion of a radial nerve splint was incorporated. No serious sepsis developed, only low grade wound infection occurring. The patient became ambulant on November 30, 1943. The wounds had healed by January 28, 1944. On February 14, 1944, Professor Sunderland reported that the radial nerve was improving and full recovery was to be expected. The extent of bone loss made bone grafting inevitable. The cast was removed on March 12, 1944, and operation was undertaken on March 16, 1944, by Lieutenant-Colonel West. Subsequent progress was excellent.

CASE III.—D.E.P. sustained a fracture of the right humerus in April, 1943, followed by non-union. A bone grafting operation was performed on February 21, 1944, an intramedullary peg of cancellous bone and Roger Anderson pins being inserted by Major MacLure. A prefabricated cast was applied as described. The patient was walking comfortably on the third day. The wound healed by first intention and convalescence was uneventful. The cast was retained for nine weeks, at which time the fracture was united.

Twelve patients with gunshot wounds of the humerus have been treated by the method described. In no instance has removal of the cast been necessitated either because of unsoundness or discomfort. All patients have been ambulant within a few days of application of the cast, and nursing has been uniformly simple.

The only problems which have arisen are illustrated in the cases reported.

SUMMARY.

1. Gunshot wound of the humerus presents the problem of a fracture difficult to immobilize, *plus* a wound or wounds, often extensive, requiring management.
2. Effective immobilization requires the inclusion of the trunk in the fixing mechanism.
3. Uninterrupted immobilization is one of the primary aims in treatment.



FIGURE V. Case III shows the cast applied. Roger Anderson pins *in situ*.

4. Access to the wound permits management by atraumatic dressings under bacteriological control, and allows minor sequestrectomies and skin grafting operations to be performed without interference with the continuity of immobilization.
5. Failure to provide access means a pus-soaked offensive cast which after a time becomes unsound. Furthermore, serious problems in regard to cross-infection are introduced.
6. A method of reconciling these difficulties is presented.
7. An adaptation of the method is also described by which prefabrication of a cast enables immediate post-operative application, and overcomes the difficulty of the application of a spica under anaesthesia.
8. Three cases are briefly reported to illustrate problems met with in the use of this method.

ACKNOWLEDGEMENTS.

I am indebted to the Director-General of Medical Services, Major-General S. R. Burston, for permission to publish this paper, and to Miss Grouse, of the Physiotherapy Department, for her assistance in applying many of the plaster casts.

PROGRESSIVE BACTERIAL SYNERGISTIC GANGRENE, WITH REPORT OF A CASE.¹

By N. J. BONNIN,
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PROGRESSIVE bacterial synergistic gangrene (symbiotic gangrene) is a rare post-operative infection of the dermis and superficial subcutaneous tissue. Causing intense pain, a gangrenous ulcer of highly characteristic appearance enlarges slowly and steadily despite all ordinary forms of treatment. Sufficient case reports have now accumulated to establish the lesion as a clinical entity with a specific bacterial cause.

The case reported here is typical of previous accounts of the disease.

CLINICAL HISTORY.

Driver G. first came under my care on December 2, 1943. His previous history had been as follows. On August 1, 1943, an acutely inflamed appendix had been removed. A fortnight later he complained of pain in the left side of the chest and a left pleural effusion developed. Aspirated fluid was found to be sterile for several weeks and then became purulent, and on October 6, 1943, a large empyema was drained. "Direct smear of the pus showed small Gram-positive cocci in chains, and on culture a *Staphylococcus aureus* and a non-hæmolytic streptococcus were isolated." The patient had shown signs of serious toxæmia during the whole of this three-month period and had needed several blood transfusions. He had not responded to administration of sulphonamides.

(It is presumed that a septic pulmonary embolus had caused an abscess of the lung; and a sympathetic pleural effusion eventually became infected from the abscess.)

On October 24, eighteen days after drainage of the empyema, "carbuncular infection" of the wound was noted. Investigation showed his urine to be sugar-free and his blood sugar curve to be within normal limits. His white blood cell count was 11,000 per cubic millimetre and differential count and film were normal. In spite of intensive local treatment with sulphаниlamide powder and perchloride packs, and repeated oral courses of sulphathiazole, the lesion slowly and steadily spread.

On December 2, forty days after the carbuncular infection had first appeared, the patient arrived at this hospital. He stated that he had suffered severe continuous burning pain since the carbuncular infection began, and except with the help of morphine he had been unable to sleep. He was pale, sallow and emaciated. He had a troublesome cough and his fingers were clubbed. He was apprehensive of the least move in bed and cried when the dressing was touched.

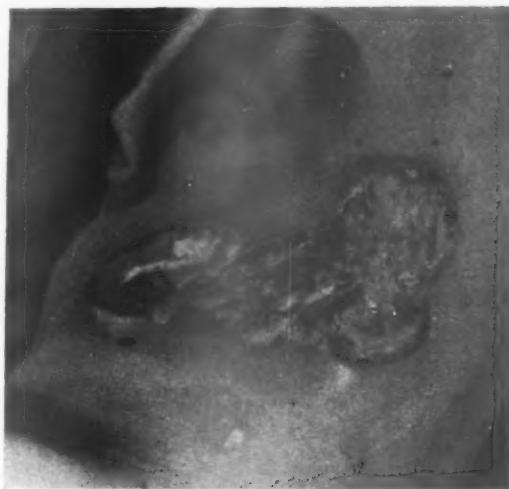


FIGURE I. The wide zone of inflamed skin surrounding the ulcer does not show in this photograph, which illustrates well the other characteristic features of the lesion.

¹ Accepted for publication on September 11, 1944.

On the left side of his chest (Figure I) was a large ulcer some 25·0 by 12·0 centimetres, with its long axis parallel to the ribs. The empyema sinus, situated centrally near the lower part of the lesion, had almost closed, but a trickle of pus oozed out when the patient coughed. The ulcer appeared to be most active in its anterior and posterior segments, whilst centrally there seemed to be some tendency to heal. At the active areas the surrounding skin was inflamed, raised and edematous for a distance of 2·0 to 3·0 centimetres. This inflamed skin was clearly demarcated into three concentric zones: an outer bright red flare, an intermediate zone raised and deep purple in colour, and an inner zone of black gangrenous skin a few millimetres wide. This gangrenous margin was undermined. The ulcer itself in its outer part was covered by masses of whitish adherent slough, but towards the centre the slough had separated in a patchy manner, exposing irregular granulation tissue. There was a copious discharge of yellowish pus. The whole lesion, and especially the inflamed skin margin, was exquisitely tender. The regional axillary lymph glands were but slightly enlarged and not tender. Signs of fluid were present in the left side of the chest below the angle of the scapula.



FIGURE II. Shows the extent of the excision.

X-ray examination showed the lower half of the left side of the chest to be radioopaque. The red cell count was 3,500,000 per cubic millimetre, the haemoglobin value was 70%, and white blood cells numbered 13,300 per cubic millimetre with a normal differential count.

Swabs from the wound were reported upon as follows: "Direct smear shows a moderate number of small Gram-positive cocci, singly, in clumps, and in short chains. On culture a staphylococcus and a small streptococcus have grown aerobically and anaerobically. A heavier growth of the streptococcus was obtained on anaerobic culture. This organism is slightly haemolytic on subculture on human blood agar."

A diagnosis was made of progressive bacterial synergistic gangrene together with a chronic empyema.

Treatment was begun by reestablishing drainage of the empyema by dilating the old sinus and inserting progressively larger tubes. On December 9 X-ray examination showed the area of opacity reduced to a costo-phrenic angle and the lung above to be of normal appearance. During this week the growing edges of the ulcer extended some 1·0 to 2·0 centimetres, and the patient suffered continuous severe pain.

On December 10, under endotracheal anaesthesia, the ulcer was excised with the scalpel. Through healthy skin a clear centimetre away from the outermost red flare an incision was made surrounding the entire lesion. The whole ulcerated area was now removed down to the level of the deep fascia. Bleeding was controlled by hot packs and silk ligature. The wound was dressed with eusol-soaked packs. Shock was controlled by massive transfusion before, during and after operation with a total of three pints of blood and 3·5 litres of serum.

Examination of the tissue which had been excised showed that immediately beneath the marginal skin there was a layer of white slough, while under this was a layer of inflamed and oedematous, but intact, subcutaneous tissue. Nowhere had the ulcerative process penetrated to the deep fascia.

Post-operatively the wound was cleansed with peroxide and dressed with eusol packs applied over a layer of *tulle gras* and frequently moistened.

This excision gave immediate relief from the intolerable pain, and rest and sleep became possible.

On December 19 recurrence of the lesion was noted at two points along the wound margin. In both these areas the skin had been retracted a little when the incision was made, so that there was slight overhanging of the cut skin edge, and in each case the process started as a white slough about a silk ligature applied close to the dermis.

On December 20, under "Pentothal" anaesthesia, the areas of recurrent ulceration were excised, again a clear centimetre away from the outermost red flare. Eusol dressings were continued. There was no further recurrence and the whole raw area soon became a smooth granulating surface and showed a healing edge (Figure II). The patient's general condition rapidly improved, and with the cessation of pain his mental outlook soon became normal.

At the end of three weeks part of the remaining raw area was skin grafted, and the graft was completed ten days later. Pinch grafts were applied about the empyema sinus and thick split skin elsewhere. In spite of the presence on the wound of the empyema sinus which was still discharging pus containing the same organisms, all the grafts "took" and by February 12 the entire lesion was healed up to the sinus.

The grafts were fixed by the "coagulum contact" method described recently by Sano,⁽²³⁾ and no pressure dressings were used. Grafts became vascularized and established with remarkable rapidity and certainty.

Though the gangrenous process had now been dealt with, the patient's condition was not satisfactory. There was still a chronic empyema causing continued toxæmia. Lipiodol examination showed an ill-drained pocket of pus and a bronchopleural fistula; and bacteriological studies of pus from the empyema sinus showed the continued presence of the anaerobic micro-streptococcus and *Staphylococcus aureus*, together with now *Bacillus pyocyanus*. In the presence of these organisms operative drainage of the pus pocket was deferred for fear of starting the symbiotic gangrene again.

At this time a quantity of penicillin became available. A total dose of 960,000 units of the drug was given parenterally by two-hourly intramuscular injections of 10,000 units, increased to 20,000 units every two hours on the last day. The drug was also applied locally in a strength of 250 units per millilitre and local application was continued for three weeks.

Penicillin treatment was begun on March 20, and on the next day the residual empyema cavity was drained by rib resection.

Bacteriological controls were carried out by Major G. A. W. Johnston. Sensitivity tests which were carried out concurrently with treatment, showed the anaerobic streptococcus to be more sensitive than the staphylococcus, while growth of the *Bacillus pyocyanus* was unaffected by penicillin. Blood bacteriostatic tests did not show uniformly complete inhibition of either staphylococci or streptococci; hence the increase in the dose of penicillin during the last day of administration. Cultures were taken daily from the wounds during the period of penicillin therapy and repeatedly thereafter during the next two months. After the second day of treatment with penicillin the anaerobic streptococcus was never again recovered, though both the staphylococcus and *Bacillus pyocyanus* were found to persist.



FIGURE III. Raw area grafted and healed.

From March 21 the patient suddenly lost all his signs of toxæmia and his general condition rapidly improved. This must in part be ascribed to surgical drainage of the residual abscess, but it seems likely that the elimination of the micro-streptococcus was also an important factor. Six weeks later the original empyema sinus finally healed.

At the end of May the patient was in good general condition and doing light work in the ward. There was, however, still a residual sinus from the last operation due apparently to osteitis of a rib and abduction of his arm was restricted by the scar. At this stage (Figure III) he was transferred to his home State.

HISTORICAL NOTE.

Although some phagedenic ulcers recorded in the older literature were certainly cases of symbiotic gangrene (Luckett⁽¹⁾ published an unmistakable case in 1909), the lesion was first described as a clinical entity by Brewer and Meleney⁽²⁾ in 1926. It happened that Brewer saw two of these cases within a short time and recognized the condition as similar to lesions described by Christopher⁽³⁾ and by Cullen,⁽⁴⁾ who had each published a case in some detail and with plates in colour in 1924. Brewer and Meleney were also able to obtain records of two similar cases from contemporary surgeons, and Meleney carefully investigated the bacteriology of one case and suggested that the disease was due to a symbiotic infection.

PATHOLOGY.

The pathological process "is best described as a spreading white subcutaneous slough" (Brewer and Meleney⁽¹⁾). This slough undermines the skin and is responsible for the elevation and purple colour of the intermediate skin zone. This white subcutaneous slough was clearly demonstrated in the present case, where it was seen both in the original lesion and in the recurrent areas. This necrotic process involves the dermis and subcutaneous tissue only; the deep fascia is not exposed and never penetrated.

The disease has usually followed surgical drainage of some infective lesion of the abdomen or thorax, and has often started about a deep tension suture. More than half of the recorded cases have followed operation upon an inflamed appendix, and next in frequency come drainage of empyema and suture of perforated peptic ulcer.⁽⁵⁾⁽⁶⁾⁽⁷⁾ General debility has been a common factor among most of the cases reported, and may be a factor in the aetiology.⁽⁸⁾

CLINICAL COURSE.

The lesion appears first as a red or purple swelling suggesting a carbuncle. However, the inflammation continues to spread slowly and steadily, causing constant intense burning pain, and in two or three weeks the central skin becomes black and gangrenous and then separates, disclosing a layer of slough. Surrounding the ulcer a wide area of inflamed skin is clearly demarcated into three concentric zones, an outer bright red flare, then an intermediate zone raised and deep purple in colour, and finally, abutting on the ulcer, a thin zone of black gangrenous skin.

Unless adequately treated the ulcer spreads slowly and relentlessly at about three to four millimetres per day until death occurs after many months, with the greater part of the trunk denuded of skin. A post-mortem photograph of a case published by Poate in 1930⁽⁹⁾ shows an ulcer extending over the whole back, from scalp to buttocks. In the granulating areas over which the disease has passed there is often a tendency to heal, and islands of skin may make their appearance. The disease does not burrow and muscles are not exposed. The authors of many of the recorded cases have been struck by the absence of general toxæmia; a low pyrexia is the rule, and the patient's appetite remains good. Exhaustion seems to result more from pain and loss

of sleep than from toxæmia, and in more than one case the patient has been cured of his disease, at a late stage, only to lose his sanity.⁽²⁾

BACTERIOLOGY.

From the first case he encountered, Meleney⁽¹⁾ recovered three organisms: a staphylococcus, a diphtheroid bacillus and a small micro-aerophilic non-haemolytic streptococcus. Outside the ulcer beneath the zone of skin inflammation he found this streptococcus growing in pure culture. Having completed cultural studies of these organisms, he tested them individually for pathogenicity, and found each of them almost non-pathogenic to animals. He then tried injecting mixed culture of the organisms and found that a mixed culture of the staphylococcus and streptococcus produced a large lesion with cutaneous gangrene. He has since been able to repeat these observations and they have been confirmed by Willard.⁽¹⁵⁾ "The demonstration that these organisms can do something together which they cannot do alone, suggests that the disease is the result of a synergistic action of the organisms, the non-haemolytic micro-aerophilic streptococcus in some way preparing the ground for the action of the combined organisms. The streptococcus is most likely derived from the intestinal canal, while the staphylococcus may come from the patient's skin or from the air" (Meleney⁽¹⁾). In the case under review, many cultures were taken at different times, and on every occasion a staphylococcus and a micro-streptococcus were recovered. Repeated cultures of the pus from the empyema sinus showed these organisms to be constantly present there. The streptococcus was anaerobic, though on one occasion a poor growth was obtained on aerobic culture. It corresponded with the organism described by Meleney, except that it was slightly haemolytic on human blood agar. After passage through a guinea-pig, however, the organism lost its power of haemolysis.

Inoculation tests were carried out on guinea-pigs, and Major G. A. W. Johnston reported as follows:

A standard volume of broth culture of the streptococcus and of the staphylococcus isolated from the wound of the patient, when injected individually into a guinea-pig, caused each a transitory reaction only; when injected in combination into another site in the same animal caused a large subcutaneous abscess after six days. The same organisms were recovered from this lesion after ten days; and their virulence appeared to be diminished when injected into a second animal. There has been no sign of gangrene in any animal; one animal has been observed for twenty-four days. 0.5 ml of pus from a patient's wound caused abscess formation of a similar type after six days.

In-vitro tests for sulphathiazole resistance were also performed, and it was found that "a 1/10,000 concentration of sulphathiazole had little inhibitory effect on the anaerobic streptococcus and fairly marked effect on the staphylococcus". This observation is in harmony with the patient's complete lack of response to sulphonamide therapy.

From time to time other organisms were recovered from the patient's lesions; these included diphtheroid bacilli, *Bacillus coli*, haemolytic streptococci, *Bacillus pyocyanus* and *Bacillus proteus*, but none of these was constantly present and their pathogenicity has not been investigated.

DIAGNOSIS.

The diagnosis of this disease rests in the main on the characteristic clinical picture. The intense and continuous pain, the three concentric skin zones—red, purple and black, with raised and slightly undermined ulcer margin—the involvement of skin and subcutaneous tissue only, with never any extension to deeper tissue, and the slow, steady, unrelenting progress of

the lesion provide a clinical picture which is not mimicked closely by any other condition. The finding of a staphylococcus with an anaerobic micro-streptococcus provides confirmatory evidence.

DIFFERENTIAL DIAGNOSIS.

Chronic undermining burrowing ulcer is another phagodermic ulcer of more frequent occurrence than progressive bacterial synergistic gangrene which it resembles in being a chronic progressive ulcerative lesion occurring occasionally as a post-operative complication and not responding to ordinary methods of treatment.

The disease, however, is quite distinct and differs from synergistic gangrene in its appearance, course and aetiology.⁽⁶⁾⁽¹⁰⁾ It is due to a haemolytic anaerobic streptococcus which invades and destroys the subcutaneous fat and the fibro-fatty planes of the body. The disease may start post-operatively or may follow any minor skin break or infective skin lesion, and occurs as frequently on the limbs as on the trunk. In contrast with symbiotic gangrene, the skin is widely undermined and the disease extends down intermuscular septa and along neurovascular sheaths, so that muscle bellies and great vessels may lie exposed in the depths of the ulcer. The undermined skin becomes thin and takes on a dull bluish-red appearance. The thin skin edge tends to curl under and the skin seems to melt away without true black gangrene. The disease is irregularly progressive over months or years, often lying quiescent in one part while it extends in another. It does not respond to ordinary methods of treatment. It can be cured by excision, but owing to deep extensions of the disease this is unlikely to be practicable. The disease is curable by application of zinc peroxide, combined with surgery designed to provide access to every part of the wound.⁽¹⁰⁾⁽¹¹⁾

The differential diagnosis of gangrenous skin lesions is very fully discussed by Meleney⁽¹⁰⁾ and by other authors.⁽¹¹⁾⁽¹²⁾ Apart from the disease described above, the main lesions which have to be distinguished are amoebic ulceration of the skin, human bite infection (fuso-spirochetal gangrene) and gangrenous impetigo. Difficulty arises only in the early stages of these diseases and the diagnosis may be established by bacterial studies. Diphtheritic cutaneous ulceration may also be confusing in the early stages.

TREATMENT.

The advent of penicillin seems likely completely to alter the treatment of this disease. In the present case penicillin was used only after the ulcer itself was cured. However, the causative organisms were found to persist in the patient's empyema and the micro-streptococcus proved to be sensitive to penicillin and was eliminated after a course of penicillin therapy. The elimination of either of the organisms in this unholy partnership would probably cure the disease, and penicillin should certainly be tried in any future case.

Apart from the possibility of cure by penicillin, up to the present the only effective treatment has been by radical surgery. Many of these patients have lain in hospital for month after month, and the terrible nature of their disease has stimulated their attendants to the trial of almost every other conceivable form of treatment, but all without the slightest benefit, and the disease has continued its steady progress unchecked.

The essential step in treatment by surgery seems to be an incision of the healthy skin and subcutaneous tissue round the lesion and wide of the outermost red zone. In one case in which this simple guttering alone was employed⁽¹⁰⁾ the lesion continued its steady advance until the gutter was

reached, when the disease burnt itself out and nowhere crossed the firebreak. Most surgeons have preferred to go on to excise the entire lesion or at least the active marginal zone. This excision must include a zone of apparently healthy skin wide of the outermost red flare. Christopher⁽¹⁾ cured his patient by excising the edge in stages. Study of the reported cases indicates that it is of little moment whether the knife or cautery be used. Meleney, who has most fully investigated the condition and has seen several cases, prefers the scalpel since this leaves a minimum of dead tissue in which infection might recur.⁽²⁾

The antiseptic dressing used on the post-operative wound does not seem to be of vital importance; it would seem that the organisms do not readily infect an open healthy wound. Their favourite starting point, it will be recalled, is a deep tension suture, and attempts to reduce by suture the size of the enormous wound left after excision have proved disastrous. In one case in which this was done⁽³⁾ the disease started afresh about each suture, necessitating further excisions.

SUMMARY.

A case of progressive bacterial synergistic gangrene which followed drainage of an empyema has been described.

Bacterial investigation showed the presence of a *Staphylococcus aureus* and an anaerobic micro-streptococcus.

Animal inoculation tests showed the organisms to be individually innocuous to guinea-pigs, but pathogenic in combination, though in the animals actual gangrene did not occur.

The ulcerative lesion was cured by wide excision followed by skin grafting.

The staphylococcus and anaerobic micro-streptococcus persisted in the chronic empyema. Exhibition of penicillin resulted in elimination of the anaerobic micro-streptococcus.

Bacterial synergistic gangrene has been discussed, and the differential diagnosis between this lesion and chronic undermining burrowing ulcer is stressed.

It is suggested that for any future case penicillin therapy should be tried before excision of the ulcer is undertaken.

ACKNOWLEDGEMENTS.

My thanks are due to Major G. A. W. Johnston and Major F. Magarey for the large amount of careful bacteriological work carried out on this case; to Chaplain G. W. A. Kircher for excellent photographs, and to Lieutenant-Colonel N. H. Robinson for helpful criticism of the early proofs.

I wish to thank the Director-General of Medical Services for permission to publish this case.

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Surgical Technique.

A DIRECTOR FOR SPLANCHNIC ANÆSTHESIA.¹

By RICHARD ORGIAS,
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An instrument has been devised to facilitate the placing of the needle point safely in anaesthetizing the splanchnic plexus.

When the abdomen is opened and the fingers of the right hand are passed down to the region of the splanchnic plexus as a guide to the needle, it is usually found that the liver, stomach and omentum obstruct the path of the needle. These organs and the rectus muscle must be displaced by retractors, a procedure which is painful, often difficult, and disturbs the patient.

The instrument consists of a thimble, with the narrow end cut off obliquely to permit the finger tip to protrude about one-third of an inch, and with a metal tube five and one-half inches long, with a bore of one-tenth of an inch, attached to the back of it.



FIGURE I.

(Figure I). As soon as the abdomen is opened the thimble is placed on the right index finger as in the drawing, and the index and middle fingers are passed into the abdomen above the stomach. The middle finger identifies the cœliac axis artery and aorta, while the tip of the index finger carrying the thimble is depressed against the posterior abdominal wall to the right of the aorta. A long anaesthetic needle may now be passed safely through the tube.

In a long operation, as the effect of the anaesthetic wears off, the injection may be repeated speedily with the help of this instrument.

Acknowledgements.

The instrument was made for me by the hospital fitter, Mr. Wilkins, to whom my thanks are due.

I also wish to thank the Medical Superintendent, Mr. John Cairney, for permission to publish this article.

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Case Reports.

CASE OF ARTERIO-VENOUS ANEURYSM BETWEEN THE BIFURCATION OF THE RIGHT CAROTID ARTERY AND THE FACIAL VEIN.¹

By J. MAXWELL CLARKE,
Lieutenant-Colonel, New Zealand Medical Corps.

A SOLDIER, Lance-Corporal F.S., was wounded in Tunisia by a mine explosion on April 20, 1943. A metallic fragment about half an inch square entered his neck on the right side behind the angle of the jaw and it lodged in the vertebral canal at the level of the intervertebral disk between the third and fourth cervical vertebrae. There was no lesion of the spinal cord. X-ray examination showed no bony damage. Slight pain was present in the occipital region on movement of the head.

He was admitted to a New Zealand general hospital on May 12, 1943. His general condition was good. There was a small healed wound on the anterior triangle of the right side of the neck about one and a half inches below and behind the angle of the jaw. In this region there was a pulsatile swelling approximately one and a half inches in diameter, having the characteristics of an arterio-venous aneurysm. There was a well marked thrill, and a bruit, loud in systole but softer in diastole, was present. In systole it was conducted widely and could be heard readily on the opposite side of the neck in the occipital region. Over the swelling the bruit was loud and of the "machinery" type. The patient complained of loud noises in the right side of the head. To some extent he became accustomed to this. There was no venous engorgement.

On compression of the carotid artery the pulsation, thrill and bruit ceased. Apparently pressure over the external carotid artery above the normal site of bifurcation caused these signs to disappear.

The patient's systolic blood pressure was 120 and the diastolic pressure was 55 millimetres of mercury; the pulse rate was 84 in the minute; the heart was not enlarged. There was evidence of a complete lesion of the cervical sympathetic. Horner's syndrome of the right eye was present, and there was lack of sweating on the right side of the face.

It seemed probable that the site of the fistula was between the external carotid and the facial vein. It was decided to postpone operative treatment and to see what progress the patient made. Towards the end of June, two months after injury, it was quite clear that the swelling was increasing in size and the pulsation was more apparent. The thrill was becoming more marked and the bruit even louder, although there was as yet no sign of enlargement of the heart and no further increase in the pulse rate. It was then decided that the operation should be performed.

Operation.

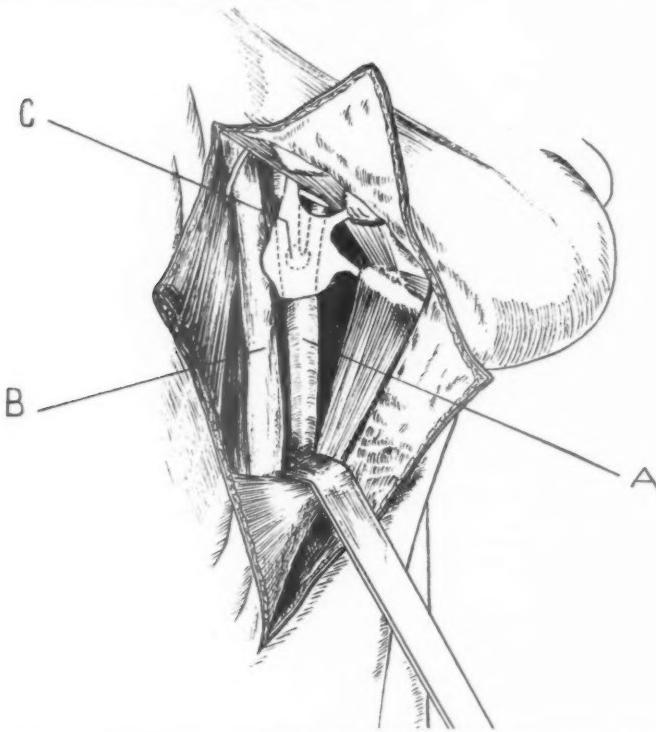
Operation was performed on July 2, 1943. General and local anaesthesia was used.

An incision was made under local anaesthesia along the anterior border of the right sterno-mastoid muscle, supplemented by one at right angles towards the chin. Local anaesthesia was used at first with the idea of testing on the conscious patient the effect of temporary occlusion of the common carotid artery. On manipulating the carotid sheath, however, the patient became distressed and general anaesthesia was begun. It was found that the common carotid artery bifurcated about one inch higher than usual. The aneurysmal leak was between the bifurcation of the common carotid and the common facial vein close to the entrance into the internal jugular vein. At this site there was considerable fibrosis and landmarks were obscured.

The common carotid artery and internal jugular vein were exposed proximally and distally to the lesion to be under complete control. While the common carotid artery was being isolated the overlapping internal jugular vein was nicked, but bleeding was controlled first by pressure and then by clamping. As the facial vein was clamped or the posterior branch of it, the aneurysmal sac, which was very thin, tore and bleeding was severe. This was controlled by digital pressure, as temporary occlusion of the vessels

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proximal and distal to the aneurysm failed to stop the bleeding. When the facial veins were free anteriorly the control became easy. Ultimately the common carotid and both internal and external carotids were ligated. The internal jugular vein and several small tributaries entering the sac were tied. The sac was extirpated. The openings of both internal and external carotids could clearly be seen from within the aneurysm. Slight retrograde bleeding occurred from the internal carotid artery before it was ligated. The vagus and hypoglossal nerve and superior laryngeal branch of the vagus were not divided. The cervical sympathetic nerve, already known to be injured, was not seen in the scar tissue. There was considerable loss of blood during the operation while the bleeding from the aneurysm was being controlled, but transfusion was carried on and the condition of the patient on his leaving the theatre was reasonably good. Four pints of blood in all were given about this period.



Diagrammatic representation of site of arterio-venous aneurysm between bifurcation of right common carotid artery and right facial vein as seen at operation. A: right common carotid artery; B: internal jugular vein; C: site of abnormal communication.

Post-Operative Course.

Central Nervous System.—Flaccid paralysis of the left arm and left leg with weakness of the left side of the face was noticed when the patient came out of the anaesthetic. This paralysis persisted until the death of the patient on July 20; but shortly a return of reflexes took place, the knee jerk returning first and being associated with a Babinski reflex. Speech was thick at first, but later became clearer. Mentally the patient was less alert than normally. Bladder control was intermittent at first; later there was incontinence.

Chest.—Respirations became irregular and rapid on July 4. Oxygen was given and afforded relief. There was early evidence of fluid at the base of the right lung and of pleurisy at the base of the left. Aspiration at the right base yielded no fluid at first, but on July 11 two ounces only of foul smelling thin frothy pus were evacuated. From this fluid grew *Bacillus pyocyanus* and *Staphylococcus albus* were grown in culture. Aspiration was not done again.

An X-ray film taken in an antero-posterior direction showed veiling at the right base, but did not suggest the presence of much fluid. It was surprising to find the amount present at post-mortem examination.

After aspiration there were occasions when the patient's breath would be foul smelling when he coughed, but there was little sputum.

General.—The patient's temperature was 104° F. on the afternoon of operation; for fourteen days it was mostly about 100° F., but rose occasionally to 102° F. Once it rose to 103° F. The systolic blood pressure on July 6 was 128 and the diastolic pressure was 75 millimetres of mercury. The pulse was regular, but increased in rate at first to 120. Later the rate settled to 88 to 100 with good volume. Finally the pulse became fast and irregular. The operation wound healed by first intention. The urine contained a moderate number of pus cells on July 15.

Blood.—On July 4 the erythrocytes numbered 3,900,000 per cubic millimetre, the haemoglobin value was 70% and the colour index 1.0. The leucocytes numbered 14,000 per cubic millimetre, and of these the polymorphonuclear cells were 69%.

On July 13 the erythrocytes numbered 4,400,000 per cubic millimetre, the haemoglobin value was 70% and the colour index 0.9. The leucocytes numbered 36,000 per cubic millimetre, and of these the polymorphonuclear cells were 92%.

On July 18 one pint of blood was given by transfusion and the haemoglobin value rose from 56% to 63%.

Chemotherapy.—When evidence of a pulmonary lesion appeared the patient was placed on sulphapyridine. The response was disappointing and administration was stopped after twenty-one grammes had been given and a change was made to sulpha-thiazole, of which twenty-two grammes were given. There was no beneficial result. The patient died on July 20 at 01.00 hours.

Post-Mortem Report.

The post-mortem report is as follows:

"The body is that of an emaciated young man. *Rigor mortis* is present. There is a surgical incision on the right side of the neck.

The Pleural Cavities: The left pleural cavity has a small amount of fibrinous exudate on the undersurface of the lower lobe of the left lung. The right pleural cavity shows an extensive walled off empyema extending from the base upwards posteriorly as high as the apex of the lower lobe and laterally to the mid-axillary line, and containing approximately two pints or more of thin yellowish pus and a certain amount of gas. The right lung shows two communications between this empyema and the lung tissue. These are posteriorly on the lower lobe and connect with three small lung abscesses. No connexion with a bronchus can be discovered. Practically the whole of the lower lobe is consolidated and in the stage of grey hepatization. Microscopically the alveoli are filled with an inflammatory exudate consisting of polymorphs and degenerate red cells. The upper and middle lobes show a patchy bronchopneumonia. The left lung shows congestion but no consolidation.

"The pericardial cavity is normal.

"The heart does not appear enlarged, but is displaced to the left and the apex is lying an inch and a half outside the nipple line. The epicardium is normal. The myocardium is pale and flabby. Microscopically it shows severe cloudy swelling. The endocardium is normal. The valves, coronary arteries and aorta are normal. The blood in the superior *vena cava* is not clotted. The right common carotid artery has been ligatured. There are no ante-mortem clots either above or below this. The left common carotid artery shows an abnormally high bifurcation.

"The oesophagus and stomach are normal. The small and large intestines are normal. The liver is of normal size. The cut surface is pale and microscopically shows cloudy swelling. The spleen is of normal size. The cut surface is flabby and mushy. The adrenals are normal.

"Both kidneys are of normal size. The capsules strip easily, leaving a smooth surface. The cut surfaces are pale. Microscopically there is a cloudy swelling and post-mortem degeneration of the tubules. The ureters and bladder are normal. The prostate is normal.

The Vertebral Column: There is a small flat foreign body lying outside the dura in the vertebral canal at the level of the intervertebral disk between the third and fourth cervical vertebrae on the left side. The spinal cord is quite undamaged at this level.

The Brain: The scalp and skull are normal. The surface of the brain shows a large area of softening and discolouration four inches in diameter in the parietal region of the right cerebral cortex. The vessels on the base of the brain show no abnormality.

There is no clotting of the right internal carotid artery and no difference in the size of the vertebral arteries. Cross-section of the brain shows a large area of softening triangular in shape, the apex at the internal capsule and the base on the surface of the parietal lobe, where it is about four inches in diameter."

Summary of Post-Mortem Findings.—The post-mortem findings may be summarized as follows: (a) multiple wounds (right elbow, right side of neck, with a foreign body in vertebral canal); (b) cerebral infarct; (c) pneumonia of right lung with lung abscesses and empyema; (d) toxic myocarditis.

Comment.

In a recent communication there was published by Lieutenant-Colonel E. S. J. King the account of a successful operation in a case of an arterio-venous aneurysm in which the fistula was between the common carotid artery and the internal jugular vein. Extirpation of the sac was performed with quadruple ligature.

The case now reported indicates the greater danger that exists when the lesion is more cephalad in site and when extirpation involves the loss of retrograde collateral circulation through the branches of the external carotid artery.

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PROGRESSIVE STREPTOCOCCAL ULCERATION OF THE SCALP WITH NECROSIS OF THE SKULL.¹

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(From the Surgical Division of the 113th Australian General Hospital.)

THE rarity of microaerophilic streptococcal infections of the skin justifies the reporting of this case. Meleney first drew attention to the difference between true microaerophilic symbiotic gangrene and progressive streptococcal ulceration. The former is characterized by the occurrence of gangrene (due to a haemolytic microaerophilic *Staphylococcus aureus*) occurring in the wake of a progressive streptococcal ulceration (due to a microaerophilic non-haemolytic streptococcus). The latter is a progressive ulceration due to microaerophilic haemolytic streptococcus, but unaccompanied by gangrene.

The clinical features and pathology of the lesion in each case are very distinctive. These should not be overlooked, as early treatment by excision is curative, and delay is therefore greatly to be deprecated.

Clinical History.

The patient was Warrant Officer V.S.L., aged thirty-four years, Australian Imperial Force. On November 23, 1942, he sustained lacerations of the arm and scalp in a motor cycle accident in New Guinea. Both lacerations were sutured at a local field hospital. The arm laceration healed rapidly, but the scalp wound became infected.

On November 30, 1942, he was admitted to an Australian general hospital suffering with "subgaleal abscess of the scalp", the scalp being very tender, the temperature 103° F., and discharging pus freely from a wound five inches long to the left of the vertex. No attempt was made to obtain a culture from the pus.

On December 4, 1942, operation was performed under "Pentothal" anaesthesia. The scalp was incised and four ounces of pus were evacuated from under the galea.

On December 5, 1942, an X-ray examination of the skull revealed no osseous lesion, and on December 11 a further collection of pus in the occipital region which had developed in the previous week required incision. Operation was performed under "Pentothal" anaesthesia. A collection of pus in the occipital region was incised and "much" pus and a large slough were removed. A course of 30 grammes of sulphanilamide was given orally.

On December 17, 1942, the patient was transferred by hospital ship, and on December 22 he was admitted to an Australian general hospital in Queensland. The condition was quiescent, and the patient's temperature 98.4° F. There was a granulating wound over the left parietal region, four inches by two inches, with a small wound behind this.

On December 26, 1942, extreme tenderness was present below the wound and fomentations were applied. On December 30 the wound was discharging, but tenderness was still present at its lower margin.

On December 31, 1942, operation was performed under "Pentothal" anaesthesia. The small wound was enlarged and was extended into the larger. The whole flap of scalp was loose. "Much" pus and necrotic tissue were evacuated.

On January 3, 1943, the patient was admitted to the 113th Australian General Hospital.

The clinical notes report that on his admission he was pale and looked ill, with a temperature of 101.4° F. and a pulse rate of 116. There was an extensive granulating wound over the left occipito-parietal region of the scalp with considerable pus and necrotic tissue. The haemoglobin estimation was 11 grammes, and no malarial parasites were seen in the blood film.

On January 8, 1943, operation was performed under "Pentothal" anaesthesia. An incision was made at the lower border of the loose flap and a "Vaseline" gauze drain was inserted. On the following day a corrugated rubber drain was inserted in place of the "Vaseline" gauze and a bacteriological culture was grown. On blood agar the predominating organism was a haemolytic streptococcus; a few colonies of *Staphylococcus aureus* and *Bacillus proteus* were also grown. On crystal violet blood agar haemolytic

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streptococci and *Bacillus proteus* were grown. A course of sulphapyridine (21 grammes) was given over the ensuing four days and the temperature became normal. The wound was dusted with sulphanilamide powder.

On January 19, 1943, despite a normal temperature, the local condition spread at the lower border of the wound and a further area of tenderness and loculation of pus occurred under the upper edge of the wound. Operation was performed under "Pentothal" anaesthesia. Through an incision posterior to the granulating wound the galea was found to be extensively undermined, and drainage tubes were inserted into the upper and lower pockets for irrigation with hydrogen peroxide. Fifty milligrammes of vitamin C were given subcutaneously every day in addition to three tablets of "Polyhæmin".

It was noted on January 30, 1943, that the local condition continued to extend, pyrexia (101° F.) recurred, the general condition showed deterioration with increasing anaemia (haemoglobin nine grammes), and I was asked to see the patient. He was dangerously ill. There was a large open wound on the left parieto-occipital region (Figure I) about eight inches in diameter. The lower edge was so undermined that it hung down like a curtain. The edges were discoloured, the skin having a purplish appearance. The epidermis was intact, but it was obvious that all the deeper layers of the scalp were involved at the wound edge. At several points the scalp was boggy and oedematous, and from these areas, which were exquisitely tender, thin greyish offensive pus could be expressed into the wound. The floor of the wound was sparsely and irregularly covered with oedematous granulations and sloughs, deficient over many areas to expose the white necrotic external table of the skull. The overhanging wound edges when lifted also revealed this bare necrotic external table. It was considered that the stages of treatment should be: (i) to maintain the general condition by blood transfusion; (ii) to excise the whole necrotic area of the scalp widely and remove the entire necrotic outer table of the skull in one or two stages; (iii) to await the control of infection and growth of healthy granulations suitable for grafting; (iv) to perform dermatome grafting of the scalp defect. This programme was carried out in the following stages.

On February 1, 1943, a transfusion of 700 cubic centimetres of citrated blood was given.

On February 2, 1943, operation was performed under "Pentothal" anaesthesia. Wide excision of the gangrenous scalp with the endothermy knife through healthy scalp was carried out. This was a tedious operation because of the haemorrhage from the healthy scalp. The haemorrhage was controlled by force-pressure and suture. The edges of the wound were carefully inspected for any signs of undermining, and their healthy condition was confirmed. All exposed bone in the operative wound was necrotic. Owing to the patient's poor general condition the operation was terminated. A pressure dressing of "Vaseline" gauze and paraffin wool was applied. Seven hundred cubic centimetres of citrated blood were infused.

Following operation, the temperature rose to 104° F., and a course of sulphathiazole was commenced. After the administration of four grammes a generalized erythematopapular rash, oedema of the face, and joint pains (especially in the wrists and elbows)



FIGURE I. Progressive streptococcal ulceration condition of scalp on February 2, 1943. Note undermining of edges and extent of spread. Note bare outer table of skull.

occurred, and the administration was discontinued. The temperature gradually subsided during the ensuing five days to 101° F., but the general condition improved slightly.

On February 6, 1943, the second stage of the *débridement* was carried out. Operation was performed under "Pentothal" anaesthesia. This was the first dressing of the wound after the first stage. The whole outer table exposed in the wound was drilled with the



FIGURE II. Showing condition after excision of wound edges.



FIGURE III. Showing condition after multiple trephining of skull to diploe.

Martel trephine to expose the bleeding diploe. This large number of holes left intervening bridges of outer table which were partially removed with the mallet and chisel. The wound was dusted with two grammes of sulphanilamide, and the pressure dressing was reapplied. Two days later a further transfusion of 700 cubic centimetres of citrated blood was given.

On February 19, 1943, operation was performed under "Pentothal" anaesthesia. The pressure dressing was changed for the first time since the previous operation. There was free discharge of pus, but no evidence of spread and no separation of residual outer table fragments. The wound was dusted with sulphanilamide and the pressure dressing reapplied.

On February 20, 1943, the post-operative reaction was severe (temperature 104° F., pulse rate 120). A course of ten grammes of sulphathiazole was administered in thirty-six hours and discontinued for fear of further toxic symptoms.

On February 26, March 5 and 12, 1943, the scalp was redressed under "Pentothal" anaesthesia.

On March 15, 1943, for the first time since the primary excision on February 2, 1943, the patient had exquisite pain and tenderness of the scalp, chiefly below the lower margin of the wound. There was a purplish fluctuant swelling in the upper part of the neck on the right side. The quiet fashion in which this arose suggested a suppurative lymphadenitis of the right upper cervical glands from the vertex where the inflammatory process had crossed the mid-line.

On March 19, 1943, operation was performed under "Pentothal" anaesthesia. Many fragments of outer table were separated as sequestra and could be removed from the invading granulations. The scalp was shaved and the wound was dusted with sulphanilamide powder and a pressure dressing was applied. The entire upper right cervical abscess was excised through healthy tissue and the cavity was filled with three grammes of sulphanilamide powder and left to granulate. The undermining of the skin edges in this region closely resembled the scalp lesion. A culture taken from the abscess showed haemolytic streptococci and *Bacillus proteus* on crystal violet blood agar medium. Haemolytic streptococci were also grown under anaerobic conditions.

On March 29, 1943, a transfusion of one litre of citrated blood was given. At this stage the whole area was covered with granulation tissue not yet healthy and still oedematous and pale. There were still many sequestra not yet separated. The dressing was now possible without general anaesthesia, and many small sequestra were picked off at each dressing with forceps. The dressings were done every third day; the whole area was washed with soap and water and dusted with sulphanilamide powder.

The patient showed considerable general improvement, but complained of photophobia and had to be kept in a darkened room. He complained too that the left half of his fields of vision was blurred. Ophthalmological examination by Major E. A. Brearley showed "pupil reactions normal, discs pale but not swollen, and visual fields taken with finger movements under a mydriatic showed an upper nasal quadrantic field defect in each eye". This was confirmed with the perimeter when the mydriatic had worn off.

On April 5, 1943, operation was performed under "Pentothal" anaesthesia. Adherent sequestra were removed with hammer and chisel, and the scalp was redressed. A tiny pocket under the lower edge of the wound, exuding pus on pressure, was radically excised; this left a wound about one inch in diameter, which was filled with sulphanilamide powder.

On April 12, 1943, there were two recurrent areas of discolouration and exquisite tenderness at the post-auricular part of the wound, about the size of a shilling. On pressure extreme pain was caused, a little pus exuded and the undermined nature of the purplish wound edge was evident. The temperature rose to 100° to 101° F.



FIGURE IV. Progressive streptococcal ulceration. Upper right cervical abscess of secondary origin. Note undermined edges and glazed granulations.

On April 20, 1943, operation was performed under "Pentothal" anaesthesia. The scalp was redressed, sequestrectomy was performed, and recurrent areas of gangrene in the wound edge were excised.

On April 25, 1943, the wound was redressed and sequestrectomy was performed under "Pentothal" anaesthesia. For the previous week the patient's general condition was so much improved that he was allowed up in the sun daily. This improvement was maintained.

On April 28, 1943, recurrent areas of gangrene were present in the anterior margin and posterior margin of the wound. These were accompanied by necrosis of the outer table of the skull for a further area of the size of a shilling. On culture the pus yielded haemolytic streptococci on crystal violet blood agar, and the same under anaerobic conditions.

Under "Pentothal" anaesthesia excision of recurrent gangrenous areas and sequestrectomy of associated necrosis of outer cranial table were carried out, and the wound was redressed.

On June 6, 1943, the infection appeared quiescent. Repeated cultures taken over the previous four



FIGURE V. Dermatome grafts successfully applied to granulations.

weeks had shown no haemolytic streptococci or *Bacillus proteus* on crystal violet blood agar. The granulations were flat and pink. The dressing was painless. The skin edges showed signs of epithelialization. No tiny sequestra were detected at the dressing. The criteria for skin grafting were therefore considered to be fulfilled.

On June 8, 1943, operation was performed under "Pentothal" anaesthesia, dermatome grafting of the granulating wound of the scalp being carried out. At operation a tiny sequestrum about 0.5 centimetre in diameter was found in the upper and anterior part of the wound. This area was not therefore covered with graft. The remainder was covered with two large dermatome grafts taken from the anterior abdominal wall, cut with the Padgett dermatome at eight divisions, sewn in position with a pressure dressing of paraffin wool and bandaged securely in position with crêpe bandages.

On June 10, 1943, slight pyrexia (99.4° F.) occurred, and the patient complained of pain in the scalp. The graft was therefore dressed. There was 75% take, and the small edge losses were excised. On June 26, 1943, the whole area had healed.



FIGURE VI. Anterior view of defect. Later the area was most successfully covered with a toupee.

On July 20, 1943, the patient was fit for discharge from the Army. The scar of the right upper neck excision was thickened and keloidal, and was subsequently excised and a local plastic operation was performed to afford comfort in shaving. A small area of breakdown at the wound edge, where the skin edge had undergone spontaneous healing, showed *Staphylococcus albus* on culture and healed rapidly under "Elastoplast". For three months the whole area has remained quite stable. Sensation is commencing to appear in the grafts.

On February 18, 1944, it was recorded that the scalp remained stable and healed.

Histopathology.

The histopathological work was carried out by Major L. J. Utz. Altogether three pieces of tissue were examined. Reports were forwarded on February 9, 1943, April 26, 1943, and May 7, 1943. The tissue in each case was taken from an advancing margin. All reports were practically identical, and read somewhat as follows:

"There was granulation tissue present and in parts dense fibrous tissue which had become hyalinized. There were patches of massed inflammatory cells (mainly polymorphonuclear cells) and many giant cells with centrally placed nuclei. No actual necrosis nor gangrene was seen, but the hyalinization of epithelial tissue probably represented the first stage towards such condition."

Comment.

The case presents two interesting aspects. The first is the typical clinical features of progressive haemolytic streptococcal ulceration without gangrene.

The differential features of this condition compared with symbiotic bacterial gangrene are set out in Table I.

TABLE I.

	Progressive Streptococcal Ulceration of Skin.	Symbiotic Bacterial Gangrene of the Skin.
Nature . . .	Acute.	Subacute or chronic.
Essential organism . . .	Microaerophilic haemolytic streptococcus.	Microaerophilic non-haemolytic streptococcus in symbiosis with haemolytic <i>Staphylococcus aureus</i> (in the areas of gangrene).
Clinical features . . .	No frank gangrene. Raised purple exquisitely tender edge Undermining of skin is very marked. Patient highly febrile and ill but apathetic.	Zone of adherent gangrenous skin. surrounded by brilliant red erythema. Undermining of skin absent or less marked. Patient ill—temperature variable—marked mental depression.
Treatment . . .	Radical wide surgical excision and subsequent grafting.	

The diagnostic features of these conditions have been aptly summarized by Stewart Wallace, thus: 1, ulceration usually follows an abscess; 2, slow but steady progressive spread; 3, involvement of superficial tissues only; 4, raised oedematous exquisitely tender and undermined skin edges; 5, relatively healthy granulating base; 6, extensive area involved, unless checked; 7, failure to respond to any non-operative treatment; 8, change in disposition of patient; 9, cure and dramatic relief of pain effected by radical excision through healthy tissue.

The second interesting aspect is necrosis of the skull. The management of necrosed skull in the seriously ill patient is a difficult problem, and the method employed in this case has been employed with success in another. It is therefore suggested that it affords a means of dealing with a bone necrosis whose spontaneous separation is very slow and not infrequently fatal.

The difficulty of complete eradication of the streptococcal ulceration of the scalp was, in my opinion, attributable to its association with necrosing outer skull table. Furthermore, this latter complication greatly increased the duration of treatment and the difficulty of dressing the bare area (because of the slow growth of granulation tissue). It was in the face of this trial to the patient that the use of "Sodium Pentothal" anaesthesia for dressings proved such a boon.

Acknowledgements.

My thanks are due to the Director-General of Medical Services for permission to publish this case report. The patient was cared for by the staff of Number 1 Plastic Centre attached to the 113th Australian General Hospital, and to their unremitting skill great credit is due. Sergeant J. Brain prepared the drawing and photographs, and the typing was done by Privates Hanson and Todd, Australian Army Medical Women's Service. For her most courteous and willing cooperation the librarian of the Royal Australasian College of Surgeons deserves my especial recognition.

Addendum.

Since this article was submitted for publication the opportunity has occurred of treating three similar cases involving the skin of the leg, and of employing penicillin therapy. In our brief experience these organisms have proved to be highly sensitive to local penicillin therapy, and have responded to the recommended dosage (250 units per cubic centimetre) employed every two or every four hours, depending on the extent of the lesion. Our experience is too short to make any positive statements, but the results to the present have been encouraging.

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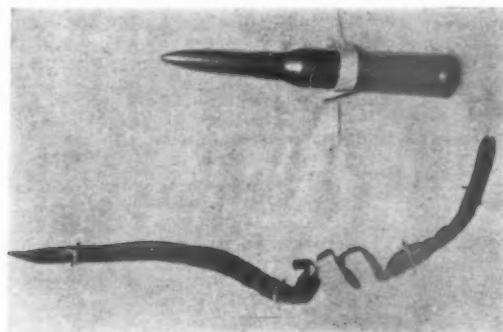
GUNSHOT WOUND OF THE ABDOMEN: AN UNUSUAL COINCIDENCE.¹

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CORPORAL N.J.B., aged twenty-five years, was wounded by a sniper on September 3, 1943. When he was examined a few hours later it was found that the bullet had entered his abdomen through a small wound situated one and a half inches above and to the left of the *symphysis pubis*, had traversed the pelvis, and emerged from a larger wound in the left ischio-rectal fossa. The abdomen was rigid and tender, mainly on the left side, but the patient's general condition was quite good. He was only moderately shocked, the pulse rate being 90. A continuous intravenous drip was commenced, and one litre of serum was given before operation.

Operation.

Approximately eight hours after infliction of the wound, under a general anaesthetic (ether given by the open method), the exit wound was excised and the abdomen explored through a left paramedian incision. The peritoneal cavity contained a large amount of urine, some blood and gas; and further examination revealed five perforations of the small intestine, averaging about one centimetre in diameter. The missile had also traversed the bladder, entering it through the fundus and emerging through the extra-peritoneal portion. The rectum had escaped injury.



While one of the larger wounds of the ileum was being sutured, the head and two inches of an exceedingly active round worm suddenly emerged through the wound from the lumen of the gut. The parasite was withdrawn, but was found to be only half a worm, having been divided about its middle. The distal portion was recovered later from the peritoneal cavity on a gauze pack. The entire worm, an *Ascaris lumbricoides*, when pieced together measured approximately six inches. The contused nature of its wounds indicated clearly that it had been divided by the bullet. Operation was completed by suture of the intestinal and bladder wounds; the bladder and cave of Retzius were drained suprapubically, and the abdomen was closed without drainage.

Post-Operative Course.

The patient made a rapid recovery. On the fourth day after operation he ate and enjoyed a meal of bully beef stew, given him by a well-meaning orderly, and was well when last seen at a general hospital some five weeks later. It was not possible—alas!—to do anything for the worm, which has been photographed together with a Japanese bullet of the type which destroyed it. Its fate is considered worth recording, since it is probably the first nematode to become a battle casualty in the war with Japan.

Acknowledgement.

I am indebted to the Director-General of Medical Services for permission to publish this case.

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Surgery in Other Countries.

[In this column will be published short résumés of articles likely to be of practical value from Journals published in other countries and not readily accessible to surgeons in Australia and New Zealand.]

A NEW TECHNIQUE FOR THE REPAIR OF THE MALE URETHRA.

Otto Lachmann: "Eine neue Plastik der männlichen Harnröhre". *Zentralblatt für Chirurgie*, June, 1943, page 909.

LACHMANN describes the technique of an operation which achieves the repair of the penile portion of the urethra in a single stage. It was performed by him on a man whose whole penile urethra had had to be excised on account of gross stricture formation.

In this technique a long doubled strip of scrotal skin is used to constitute both the floor of the new urethra and the covering skin over it. Two parallel incisions are made close together on each side of the ventral surface of the penis, the median two being about eight millimetres apart, and these two are carried downward down the anterior surface of the scrotum right to its lower pole. The lower pole of the scrotum is then brought up to the *glans penis* so that the median penile incisions and the two scrotal incisions lie in apposition and can be sutured together. This suture is made with fine gut and with great care to adjust the elastic tissue of the scrotum to its correct position on the penis at each suture. From the spot on the lower pole of the scrotum where these two incisions end two similar incisions are carried backward down the under surface of the scrotum right to the perineum. These are deepened, and the two halves of the scrotum are carefully separated, a bridge of scrotal skin still being left attached to its underlying connective tissue and blood supply. At the perineal end these two parallel incisions are joined by another, convex posteriorly, going through the skin only. The skin and connective tissue bridge is mobilized in a forward direction, so that the two halves of the scrotum can be sutured together behind it. The edges of the bridge are sutured on each side to the lateral of the two incisions originally made on the underside of the penis, and the operation is complete. A small drain is placed in the angle of the wounds at the peno-scrotal junction and a catheter is put in position and left for eight days.

The operation is followed by considerable swelling, which, Lachmann states, can be controlled by compresses moistened with 3% calcium chlorate solution. It can be easily performed with local analgesia, and with the addition of adrenaline there is little bleeding. Healing in the case reported was satisfactory, the blood supply of the various parts being apparently quite sufficient.

ARTHUR E. BROWN.

ON THE OPERATIVE TREATMENT OF ACUTE HÆMORRHAGE FROM PEPTIC ULCER.

Gustav Seidl (Wiener Städt Krankenhaus, Lainz): "Zur Frage die operative Behandlung der akuten Ulcusblutung des Magens und Duodenum". *Zentralblatt für Chirurgie*, April, 1943, page 603.

SEIDL opens his article with a discussion of the history of surgical ulcer treatment, in which he pays due tribute to Finsterer's work in bringing the desirability of early operation into correct perspective. Winkelbauer, the head of the Lainz clinic, adopted the principle in 1941, and showed the danger of conservative treatment, especially in older patients. Since then early operation has been the rule at Lainz, and patients with massive hæmatemeses are either admitted direct to the surgical wards or else medical investigation is carried out in close conjunction with the surgical staff. As a result, though each case is judged on its merits, an increasing number of patients are now operated upon within forty-eight hours of the onset of bleeding, with a corresponding improvement in results. From 1931 to 1938 nineteen patients were treated by operation after conservative treatment, with a total mortality of 42%. Death is considered to be due largely to the irreversible damage wrought by prolonged severe anaemia. During the next two and a half years, forty-eight patients were treated by operation, thirteen of them within forty-eight hours of onset, and the rest after some delay owing to doubts as to the diagnosis. Only four deaths occurred in this series. Two of them occurred among those having delayed treatment, and the other two among those in whose treatment some palliative method of arresting the bleeding had been unsuccessfully

attempted. Seidl considers that some at least of these patients might have been saved by early radical operation. The shocked condition of the patient should be no bar to early operation, for the shorter the time elapsing between bleeding and gastrectomy, the better are the results. General anaesthesia is avoided in the treatment of these anaemic patients, whenever it is possible to do so, and all operations have been carried out with local analgesia of the abdominal wall combined with the usual splanchnic infiltration.

The condition is an especially dangerous one in elderly patients, and in these it is imperative to prevent the onset of a severe anaemia, which is most safely achieved by early operation. In young people it is unusual to see similar grave effects, but one of the patients whose history is reported by Seidl was a boy of nineteen years. The major difficulty lies in excluding with certainty all causes of gastric haemorrhage other than chronic ulcer. In this regard it is to be borne in mind that failure to demonstrate the ulcer radiographically does not prove that it is not present. If necessary, an exploratory laparotomy and even an exploratory gastrotomy carry fewer risks than leaving a bleeding patient untreated. And a surgeon who decides on operation only after long-continued unsuccessful medical treatment, must expect a high mortality among those patients on whom he does operate.

ARTHUR E. BROWN.

Reviews.

The Modern Management of Colitis. By J. ARNOLD BARGEN, M.D.; 1943. Springfield, Illinois, United States of America: Charles C. Thomas. London: Baillière, Tindall and Cox. Pp. 332, with 148 figures. 9½" x 6". Price: \$7.00.

"THE MODERN MANAGEMENT OF COLITIS" is the title of a book written by J. Arnold Bargen, chief of the Section on Intestinal Diseases, Mayo Clinic.

The book deals with the diagnosis, treatment and complications of all forms of intestinal infections. It contains the observations of the author which have been based upon the enormous clinical material of the Mayo Clinic. Clinical, laboratory, proctological and Röntgenological criteria are dealt with in great detail. The irritable colon, types of ulcerative colitis, thrombo-ulcerative colitis, streptococcal regional ulcerative colitis, chronic ulcerative colitis are types of ulcerative colitis which are exhaustively described. The relation of colitis to food and vitamin deficiency is discussed.

The book is clearly written, well illustrated and excellently produced. It must be regarded as an authoritative work on the treatment of colitis.

Demonstrations of Physical Signs in Clinical Surgery, Ninth Edition. By HAMILTON BAILEY, F.R.C.S.; 1944. Bristol: John Wright and Sons, Limited. Pp. 359 with 492 figures. Price: 25s. net.

THIS unique pictorial record of the physical signs in clinical surgery makes its appearance in a ninth edition in a somewhat smaller form than that of the previous editions, but with more coloured photographs in addition to the many black and white studies. It remains, as ever, an admirable guide to clinical examination for students and practitioners alike. The completeness and lucidity of the photographic illustrations have yet to be equalled; and this book, already known throughout the world, can be confidently recommended and goes to prove that physical examination is not yet a lost art.

The 1943 Year Book of Industrial and Orthopedic Surgery. Edited by CHARLES F. PAINTER, M.D.; 1943. Chicago: The Year Book Publishers, Incorporated. 7" x 4½". Pp. 440, with 306 figures. Price: \$3.00.

PUBLISHED in the series of Practical Medicine Year Books, this little volume has, in keeping with the regulations of the War Production Board, been reduced in size and condensed, but nevertheless contains notes of most of the latest advances in orthopaedic surgery and industrial medicine.

In the part devoted to orthopaedic surgery the treatment of war injuries of limbs involving bone is naturally thoroughly reviewed, and the work of Patey and Robertson on crush syndrome and renal failure occurring in air raid casualties and its prophylaxis is noted. Advances in the treatment of fractures and dislocations are summarized, as are innovations and new views on the pathology and treatment of the various arthropathies. The Kenny method of treating poliomyelitis, at present receiving enthusiastic

approval in the Middle West, receives fair and dispassionate comment, and recent technique for leg lengthening and bone grafting is described.

The second part of the work deals with problems met with in the sphere of the industrial medical officer. As the author points out, the large scale manufacture of munitions has tremendously increased the hazards to the health of those engaged in their production, and the medical practitioner on the "home front" must be prepared to cope with disabilities arising therefrom. In addition to a review of the cause and treatment of various occupational diseases, subjects such as absenteeism and industrial fatigue are dealt with in the light of recent experience.

This book forms a very useful reference volume for the surgeon or industrial medical officer dealing with disabilities arising from trauma or occupation. References are freely given and the illustrations are excellent. The "orthopaedic practice quiz" embroidering the paper covering is novel and interesting, but surely journalistic rather than academic.

Manual of Human Protozoa. By RICHARD R. KUDO, D.Sc.; 1944. Springfield, Illinois: Charles C. Thomas; London: Baillière, Tindall and Cox. $7\frac{1}{2}'' \times 5''$. Pp. 134, with 29 figures. Price: \$2.00.

In this small volume, by a well-known American protozoologist, the 27 species of protozoa which parasitize man are described, and an account of their life histories is given. The book does not pretend to compete in scope with the authoritative works of Wenyon, Dobell and others; it is rather a short but clearly written exposition, based on the author's laboratory notes which he has used for an emergency course at Illinois University. There are several chapters on simple but effective laboratory technique for the detection and identification of both intestinal and circulatory parasites. Illustrations are abundant and clear, but not coloured. The book may confidently be recommended to all those laboratory workers who are called upon to deal with the menace of protozoa in the tropics, and its publication at the present moment is therefore very opportune.

Advances in Internal Medicine, Volume I. By J. MURRAY STEELE; 1942. United States of America: Interscience Publications, Incorporated; Melbourne: W. Ramsay (Surgical) Proprietary Limited; Sydney: The Grahame Book Company; Angus and Robertson, Limited. $9'' \times 5\frac{1}{2}''$. Pp. 303, with 19 illustrations. Price: \$4.50.

WHILE this book is primarily intended for the physician, it contains many sections of great interest to the surgeon. Each section consists of a summary of recent advances in a particular field of research, and in most cases the authors have contributed materially to research in the field of which they write. Each section is complete in itself, is very clearly written and has a summary and a bibliography.

W. Osler Abbott contributes a section on the use of the Miller-Abbott tube. Its value in paralytic ileus and small bowel obstruction is well known, but the author points out that it is of use in colonic surgery as a preparatory measure, and quotes figures to show a greatly decreased mortality from surgical procedures applied to this colon in which it was employed. He states that, when combined with therapy by the sulphonamide drugs, it has been a useful adjunct in the treatment of peritonitis, controlling the distension and allowing subsidence of inflammatory obstruction to occur. He draws attention to some of the difficulties and dangers of the employment of the tube in intestinal intubation.

R. W. Wilkins discusses very fully, from a physiological point of view, the sympathetic control of the peripheral vascular system. He gives a clear physiological basis for the signs and symptoms of Raynaud's disease, acrocyanosis, Buerger's disease and peripheral neuritis. He draws attention to the relation of hyperactivity of the sympathetic nervous system to arterial hypertension.

In shock the acute peripheral vasoconstriction found characteristically is said not to be primary, but to be secondary (or compensatory) to the collapsed state of forward failure of the circulation. Referring to the syndrome of intermittent claudication which is generally believed to be due to inadequate arterial supply to the muscles and limbs, Wilkins states that it is not favourably influenced by the sympathetic denervation of the affected part.

C. N. Keefer discusses absorption, excretion and toxicity of the sulphonamides, and concludes that sulphadiazine is as effective as the other sulphonamides at present known, causes less toxic effects, and appears to be the drug of choice at present for the treatment of those diseases known to respond to sulphonamide drugs.

Among other sections that will interest the surgeon in this book is one on hypertension by I. H. Page and A. G. Corcoran. Discussing the operative treatment of hypertension, these authors mention that the results of supradiaphragmatic and

subdiaphragmatic sympathectomy are reported as being very mixed, and the results of total sympathectomy, while being consistent with a normal existence by the patient, have not yet been sufficiently studied to warrant definite conclusions.

This book will be a valuable addition to any surgeon's library.

Office Endocrinology. By ROBERT B. GREENBLATT, B.A., M.D., C.M.; Second Edition; 1944. Springfield, Illinois: Charles C. Thomas; London: Baillière, Tindall and Cox. Pp. 255, with 48 figures. Price: \$4.00.

In this little book the author has set out very concisely and clearly the "endocrine answer" to many problems such as the management of climacteric patients, sterility, habitual abortion, hirsutism, and in the male hypogonadism, cryptorchidism and gynaecomastia. In each case the symptoms and signs of the trouble are set out concisely, and the management and treatment are considered in detail. Full references and tables are given, and these show the dosage and type of the present commercial preparations in use; the latter part of the book consists of a clinical evaluation of oestrogens and androgens. The author discusses a method whereby long continued action of endocrine drugs may be brought about by the introduction into the rectus sheath of chemically pure crystallized tablets of estradiol, progesterone or testosterone propionate.

This little book, which might serve as a model of how to set out clearly and concisely the accepted views on any practical subject, should be of great use to all practitioners as a handy reference book in applied endocrinology.

Forward Surgery in Modern War. By W. H. OGILVIE, M.A., M.D., M.Ch., F.R.C.S., Hon. F.A.C.S., Hon. F.R.C.S.(C.); 1944. London, Sydney, Wellington: Butterworth and Company (Publishers) Limited. 5 $\frac{1}{2}$ " x 8 $\frac{1}{2}$ ". Pp. 96, with 12 illustrations. Price: 14s., postage 6d.

This is a short easily carried primer for the surgeon in forward areas, being authoritatively written by the consulting surgeon to the British Forces in East Africa and the Middle East from 1942 to 1944.

The book is concise, clear, dogmatical and up to date; it includes a note on penicillin. Most of the practice advised is the standard practice in the Australian as well as the British Army, and much of it has been developed by Australian surgeons in the Middle East, particularly with regard to the abdominal surgery.

Of particular interest are: notes on the collection of whole blood before a battle; notes on the making of wet plasma by the bank transfusion unit; the description of a detailed technique of *débridement* or prophylactic excision of wounds; insistence on the early removal (in order to prevent progressive shock and later liver or renal damage) of incendiary bullets, which make their presence known by reason of smoke issuing from the wound; the section on the after-treatment of arterial injuries by warming the body and cooling the affected limb, and also by repeated injections to the stellate lumbar sympathetic ganglia; reference to the mobilization and exteriorization of all colon wounds; advocacy of the use of routine gastric suction in the treatment of abdominal wounds; the fact that chest wounds are only operated on if haemorrhage, infection, or a sucking hole is present.

The author's list of seven deadly sins of field surgery are worth quoting. They are: (i) Wound suture. (ii) Unnecessary excision of skin. (iii) Insufficient incision of fascial planes. (iv) Tight plugging. (v) Unsplit and unpadded plasters. (vi) Unnecessary drastic operation for simple wounds and gas cellulitis. (vii) Failure to forestall gas gangrene and to recognize it when it appears.

This little book will be of help and interest to any who have to deal with the early treatment of war wounds.

Tuberculosis of the Ear, Nose and Throat. By MERVIN C. MYERSON, M.D.; 1944. Springfield, Illinois: Charles C. Thomas; London: Baillière, Tindall and Cox. 9" x 5 $\frac{1}{2}$ ". Pp. 300, with 88 figures. Price: \$5.50.

This is a valuable book and deals with an important clinical subject. Tuberculosis of the upper food and air passages is not uncommon, and information about it in the textbooks is somewhat sparse and inaccessible to the average reader. It is therefore very convenient to have the subject dealt with in a compact volume. The author writes with authority on the subject and his style is clear and lucid and entirely free from American colloquialisms.

Tuberculosis of the larynx is considered in great detail in the opening chapters; in fact, this subject occupies more than half the book. The author is of the opinion that

the disease reaches the larynx by the blood stream and not by infection from the sputum. The pathology of this condition is dealt with in great detail. The question of tracheotomy for laryngeal tuberculosis is admirably discussed. Valuable information is given about the use of the galvano-cautery in this disease. There is a useful chapter on non-tuberculous laryngeal lesions as seen in tuberculous patients. The section on tuberculous *otitis media* is also excellent. The author does not favour the view that infection reaches the middle ear through the Eustachian tubes. He advises radical surgery when conservative treatment is not adequate. The chapter on tuberculosis of the mouth, nose, sinuses and trachea contains information difficult to obtain elsewhere. The author favours, in certain circumstances which are adequately discussed, diagnostic bronchoscopy for tuberculosis of the lungs. He states that over one thousand patients have been so examined. He adds, however, that bronchoscopy for treatment has only limited value.

Illustrations are plentiful and well chosen and some of them are quite original in design. An extensive bibliography is appended to each chapter. We recommend the book with confidence to all those whose work lies within its scope.

Illustrations of Regional Anatomy, Fifth Edition. By E. B. JAMIESON, M.D.; 1944. Edinburgh: E. and S. Livingstone. Section I, Central Nervous System, 50 plates; Section II, Head and Neck, 64 plates; Section III, Abdomen, 44 plates; Section IV, Pelvis, 35 plates; Section V, Thorax, 32 plates; Section VI, Upper Limb, 42 plates; Section VII, Lower Limb, 52 plates.

THE fifth edition of "Illustrations of Regional Anatomy", by E. B. Jamieson, Senior Demonstrator and Lecturer of the Anatomy Department of the University of Edinburgh, has just been published. Seven sections, separately bound or in one volume—"Central Nervous System", "The Head and Neck", "The Abdomen", "The Pelvis", "The Thorax", "The Upper Limb" and "The Lower Limb"—comprise this complete set of illustrations.

Fine art paper, accurate drawings of anatomical dissections, of transsections, and other anatomical preparations, all vividly coloured, make this work an extraordinarily useful anatomical atlas which can be used in conjunction with textbooks for the student or for quick reference for the busy surgeon.

That this work should so soon attain its fifth edition shows the appreciation it has met with in anatomical circles. In this new edition many new colour blocks have been added. In Australia it is deservedly popular among students of anatomy, who consider themselves lucky to have at their disposal such a lucid reflection of the teaching of an anatomical department so famous as that of the University of Edinburgh.

Psychiatry and the War. Edited by FRANK J. SLADEN, M.D.; 1943. Springfield, Illinois: Charles C. Thomas; London: Baillière, Tindall and Cox. Pp. 486. Price: \$5.00.

THIS book is a record of the proceedings at a conference on psychiatry held at the invitation of the University of Michigan and Macgregor Fund at Ann Arbor on October 22, 23, and 24, 1942.

There are five main parts: the philosophy of psychiatry; research in psychiatry; psychiatry in the training, experience and education of the individual; psychiatry and the war; and, finally, review of these parts in two symposia. In the first four parts thirty-four American and Canadian psychiatrists, among whom are several well-known names, submit lectureettes of about twelve pages each. With such a number of contributors it is natural that some of the contributions are of higher standard than others.

The field covered is immense, embracing the place of psychiatry in general medicine, surgery, paediatrics, geriatrics, research, society, the armed forces, civilian defence, international affairs, industry, and many other spheres.

The contributions by the representatives of the armed forces are too short, but are of excellent material. Treatment is not discussed.

Surgeons will be interested chiefly in the one hundred and forty cases of prefrontal lobectomy that are discussed by Walter Freeman. In the chapter concerning the place of psychiatry in surgery it is stressed that many psychiatric conditions resemble thyroïd, gynaecological, abdominal disease or the disability that results from prolapsed discus.

In general survey it might be said that the conference must have been of immense interest and value; but the recording of the proceedings in book form has not been entirely successful. Most readers would find something to interest them in their particular sphere, but concentration and time will be needed to find it. The book is primarily of interest to the psychiatrist, the psychologist and the social worker. It is not of great interest to the surgeon.

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